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Exploring the potential of artificial intelligence for improving on-site construction logistics:

Opportunities and challenges

Master's thesis in Design and Construction Project Management

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Exploring the Potential of Artificial Intelligence for Improving On-site Construction Logistics

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ABSTRACT

The construction industry continues to face multiple challenges related to on-site logistics, including fragmented information flows, inefficient material handling, limited space availability, and reactive planning practices. These challenges are particularly significant in urban construction projects, where restricted access and dynamic site conditions increase the complexity of logistics operations. At the same time, recent advances in Artificial Intelligence (AI) have created new opportunities to support decision-making, optimize resource utilization, and improve coordination across construction processes. The aim of this thesis is to explore how AI can support on-site construction logistics and to identify both the opportunities and barriers associated with its implementation. The study was conducted through a qualitative research approach combining a literature review with semi-structured interviews involving logistics managers, consultants, coordinators, and other industry practitioners.

The findings indicate that many logistics-related problems originate from insufficient early-stage planning, fragmented communication between stakeholders, and a predominantly reactive approach to logistics management. Interviewees generally expressed positive attitudes toward AI and multiple areas were identified that have significant potential for AI implementation such as decision support, planning optimization, data integration, clash detection, traffic routing, and automation of administrative tasks. However, several barriers were also identified, including low digital maturity, poor data quality, organizational resistance to change, and the highly contextual nature of construction projects. The study concludes that AI has considerable potential to improve on-site construction logistics, primarily as a decision-support tool rather than a replacement for human expertise. Successful implementation depends not only on technological capabilities but also on improvements in data management, organizational readiness, and the integration of logistics considerations into early project planning. The results suggest that gradual adoption of AI-supported processes may provide the most realistic pathway toward more efficient and proactive construction logistics management.

Key words: Artificial Intelligence, Construction Logistics, On-Site Logistics, Construction Management, Digitalization

Content

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Jannik Severin Kirchner & Tony Yasso

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List of Figures

1 Introduction

How construction work is planned, coordinated and performed in practice is central to achieving successful building results. The infrastructure that supports daily life reflects the importance of the construction sector to the development of societies. Small interruptions of material and resource flows at construction sites rapidly impair productivity, safety and progress, and underline the importance of effective management of these flows to project performance. Adequate solutions to the expectations for modern construction require attention not only to technical design solutions, but also to the operational mode of construction. With increasing rates of urban expansion and increasing complexity of projects, construction must provide results that are safe, predictable and consistent with overall objectives of sustainability in addition to being economically attractive and completed on schedule.

1.1 Background and problem context

The construction sector has experienced relatively low productivity growth compared to several other industries, despite continuous technological development and increasing digitalization. In Sweden, this challenge is particularly evident in urban construction projects, where limited space, complex stakeholder coordination, and high logistical intensity put significant pressure on project execution. In such projects, activities that are sometimes treated as support functions, such as construction logistics, can have a substantial influence on production flow, time performance, and overall project efficiency (Forsemalm, 2023; Janné, 2021).

Construction logistics involves planning and managing the flow of materials and equipment to and within a construction project. This includes both off-site logistics (e.g., supplier coordination and transport planning to the site) and on-site logistics (e.g., deliveries at the gate, unloading, storage, internal transport, lifting operations, and spatial coordination of resources within the site). This thesis focuses specifically on on-site logistics, since it represents the direct interface between logistics planning and production execution and is strongly affected by spatial constraints and day-to-day coordination on site (Fredriksson et al., 2024; Janné, 2021). These activities are key for ensuring smooth production flows; however, they are often treated as lower-level support functions. As a result, construction sites frequently experience congestion, material shortages or surplus, double handling, waiting time, and poor utilization of space and equipment (Fredriksson et al., 2024; Janné, 2021).

Research has shown that a significant share of non-value-adding time on construction sites is related to logistics-related disturbances, including late deliveries, lack of coordination between trades, and insufficient planning of site layouts (Forsemalm, 2023). Such inefficiencies can increase project cost and duration through additional transportation, material waste, and unused machinery.

In dense urban environments such as Gothenburg, these challenges are further amplified. Construction projects are often constrained by limited storage space, restricted access routes, strict delivery time windows, and proximity to surrounding traffic and buildings. Consequently, effective on-site logistics has become a critical success factor for project performance, safety, and sustainability .

1.2 Digitalization and the emergence of AI in construction logistics

Recently, digitalization has been promoted as a key driver for improving efficiency and coordination within the construction sector. Technologies such as Building Information Modelling (BIM), digital scheduling tools, and logistics planning systems are increasingly used to support project planning and execution. However, despite these developments, decision-making in on-site logistics remains largely experience-based and reactive rather than data-driven (Janné, 2021)

Artificial intelligence (AI) is a promising tool for supporting complex decision-making in industries that are characterized by uncertainty, multiple constraints, and dynamic environments. Within construction, AI has primarily been discussed in relation to design automation, cost estimation, risk analysis, and scheduling optimization. Its potential role in construction logistics, particularly on-site logistics, has received comparatively less attention, despite the high level of complexity and data intensity associated with logistics operations (Fredriksson et al., 2024; Lindholm & Lundberg, 2022).

AI-based approaches have the potential to support logistics planning by identifying patterns in historical data, predicting bottlenecks, optimizing resource allocation, and supporting scenario-based decision-making. AI systems, for example, can help optimize delivery scheduling by predicting likely congestion on specific corridors. They can identify feasible site solutions by studying alternative designs or helping the trucker choose the most optimum plan .

Rather than replacing human decision-makers, artificial intelligence (AI) can function as a decision-support tool that enhances situational awareness and improves the quality of planning decisions. However, implementation of AI in construction logistics is not straightforward. Many studies indicate that new technologies pose important challenges to companies such as data availability and quality, fragmented information flows, lack of digital maturity, and organizational resistance to new technologies (Fredriksson et al., 2024; Lindholm & Lundberg, 2022). In this aspect, there is a lack of information on practical guidelines and recommendations on how AI solutions can be implemented and effectively used within existing logistics processes and structures.

1.3 On-site logistics in the Swedish construction context

In Sweden, construction logistics has gained increasing attention in both research and industry practice, particularly in relation to urban development projects. Publications from Janné (2021) and Forsemalm (2023) emphasize that logistics planning is often introduced too late in the project lifecycle, leading to reactive management of material flows rather than proactive and structured planning. This late involvement often results in inefficient use of resources, poor coordination between actors, and increased disturbances during production.

To address these challenges, specialized logistics service providers have emerged, offering structured logistics planning and coordination services tailored to construction projects. One such company is Bygglogistik, based in Gothenburg, which focuses on improving construction efficiency through coordinated deliveries, material handling, and on-site logistics planning. Their work reflects a growing recognition within the Swedish construction industry that logistics management must be addressed as a core strategic function rather than a supporting activity (Bygglogistik, n.d.).

Despite these developments, the application of advanced digital decision-support tools, particularly AI-based solutions, remains limited. Logistics planning is still largely based on manual scheduling, experience-based judgment, and static planning documents (Fredriksson et al., 2024; Janné, 2021). As a result, there is a clear gap between the potential of digital and AI-based methods and their actual use in construction logistics practice. Addressing this gap requires not only technological development but also an understanding of organizational readiness, data availability, and implementation strategies.

1.4 Research aim and purpose

The overall aim of this thesis is to investigate how AI can be applied to improve on-site construction logistics, with a particular focus on decision-making, planning efficiency, and resource coordination.

The study seeks to:

- Identify key challenges in current on-site logistics practices,
- Explore how AI-based methods could support logistics-related decision-making.

The research is conducted in collaboration with Bygglogistik, providing an empirical foundation grounded in real construction projects and logistics operations.

1.5 Research questions

The following research questions will be answered throughout this thesis:

- What are the most common challenges that practitioners face in on-site logistics?
- How can AI support various processes for on-site construction logistics, such as construction site layout, crane location optimization, transport coordination, and space utilization?

1.6 Limitations

This work is primarily based in the Swedish construction context, as empirical interviews were obtained with practitioners working on Swedish projects and organizations. In addition, the review of the literature included both Swedish and international sources, especially with regard to fundamental concepts of AI, implementation methodologies and examples of application to construction logistics. Any kind of AI system, algorithm, or software was not developed. Instead, the major contribution was to identify major on-site logistics problems and to describe the potential for application of AI to processes and decisions of construction logistics. Therefore, the results represent a basis for further work and indicate the requirements, conditions for data collection and limitations of practical application that must be satisfied by an AI-based system operating within the context of actual construction projects.

2 Method

The theoretical basis for examining the possibilities for implementing AI to improve on-site construction logistics is the focus of this thesis. With respect to identifying common problems of on-site logistics, the review attempts to identify opportunities for improved planning and coordination in practice.

Three objectives consistent with the research questions for the thesis define the literature review. Finally, the conditions for later chapters are provided by conceptualizing AI as support for repeated decisions under uncertainty and summarizing conditions for adoption and implementation. Common on-site logistics problems are synthesized in the second objective, and typical underlying conditions for urban construction are described. Finally, definitions of boundaries for on-site construction logistics are provided, and major processes of on-site performance are described.

2.1 Research method

This thesis is based on a qualitative research approach. The objective is to develop a detailed understanding of (1) typical problems associated with on-site logistics and (2) ways in which AI could support decisions and planning logistics activities, focusing on on-site logistics.

Because the aim of the study is to examine "how" and "why" logistics problems arise and to evaluate potential approaches for integrating AI into actual workflows, qualitative interviews provided an appropriate basis for obtaining views, experiences and modes of reasoning of practitioners involved with on-site logistics.

The work was conducted in collaboration with Bygglogistik as the major source of information, and included representatives of various perspectives on logistics planning, coordination, project implementation and capacity for digitalization and application of AI. However, perspectives from other companies and practitioners were investigated and taken into account which makes the results applicable across the construction logistics industry.

The study uses an iterative and temporally structured approach in which each successive phase informed and was informed by previous phases. Initially, the scope of the thesis was identified and established collaboration with Bygglogistik. Based on this initial scope, preliminary research questions were developed and shared with both the company and the supervisor. With the following feedback, the research questions were further developed to achieve high levels of practical relevance and emphasis on on-site construction logistics and application of AI as a decision support tool. Subsequently, an initial review of the literature was performed to obtain information on (1) typical problems associated with on-site logistics, (2) areas of logistics-related decision making, (3) opportunities for application of AI to construction logistics, and (4) barriers to implementation. The results were used to develop a semi-structured interview protocol that ensured identical core questions for all interviewees and provided direct support for the research objectives.

Specifically, the interview protocol included 0 to 11 groups of questions addressing:

0. Background
1. On-site logistics scope
2. Typical problems/challenges
3. Consequences
4. Root causes
5. Key decisions
6. Current way of working (data/tools)
7. Current AI use
8. AI Potential
9. Barriers to AI adoption
10. Risks
11. Practical first step

The entire interview guide can be found in the Appendix.

All interviews were audio recorded with permission of the interviewee, transcribed and converted to structured formats in which each question was followed by a bullet summary of the response.

Finally, throughout the process of data collection and analysis, results were continuously evaluated in comparison with the literature to facilitate interpretation, improve focus, and achieve consistency between theoretical and practical perspectives.

2.2 Literature review

A literature review was conducted to create a theoretical foundation for the thesis and to support research questions. The literature review focused on:

- Construction logistics and on-site logistics (definitions, processes, challenges),
- Decision-making and planning in on-site logistics (e.g., layout, deliveries, space, resources),
- AI in construction and logistics (as decision support rather than tool development),
- Barriers and readiness factors for AI adoption (technical, organizational, cultural).

The literature search was performed with the assistance of Chalmers library databases and additional sources (e.g., Swedish industry reports on and academic theses related to construction logistics). Combinations and iterations of keywords were based on results obtained, for example, on topics including construction logistics, on-site logistics, delivery planning, layout design, crane planning, urban construction, Sweden, methods of decision support, application of AI to construction, digitalization and barriers to implementation. The resulting selection was further restricted by critical evaluation of titles and abstracts and by priority to sources directly related to (1) problems of on-site logistics and (2) conditions for practical implementation in construction.

Because the present thesis was developed for the Swedish context, priority was given to Swedish research and industry publications where appropriate. However, extensive use was also made of international scientific literature to provide strong support for concepts of decision support not fully developed in the Swedish literature (e.g., problems of integration of layout and resources).

2.3 Interview study

2.3.1 Interview design

The primary data collection was semi-structured interviews. This approach makes it possible to maintain a consistent interview format (and thus achieve high levels of comparability across interviews), while at the same time encouraging participants to provide extensive elaboration and describe relevant examples from their experience.

The interview guide was developed from:

- The thesis research questions, and
- The main themes identified in the literature review (on-site logistics scope, typical problems, causes, decision areas, AI use today, AI potential, barriers, risks, and practical first steps).

To facilitate focused and easily provided responses, open-ended questions were used that receive general descriptions of the typical problems associated with on-site logistics, reasons for the occurrence of these problems, and types of activities which AI could assist with.

2.3.2 Interview sample and roles

The interview sample was selected to include roles that represent both strategic and operational perspectives, such as:

- Management/business roles,
- Logistics planning roles (early-stage planning and layout),
- On-site logistics coordination roles,
- Administrative/data-related roles.

This role variation supports triangulation across perspectives and helps identify whether the same logistics issues and AI-related needs are shared across the organization or differ by role. A total of 12 interviews were conducted for the interview study.

2.3.3 Interview procedure, recording, and transcription

Interviews were conducted in English with flexibility for Swedish responses when preferred. All interviews were structured in the same overall format (0 to 11 groups of questions: background, extent, difficulties, consequences, causes, important decisions, current methods of operation, present use of AI, potential for AI, barriers to implementation, first steps and associated risks). Responses were recorded with the consent of the interviewee and transcribed afterwards using the Chalmers AI Portal.

2.3.4 Thematic analysis

The interview data was analyzed using thematic analysis, where patterns and themes were identified across interviews. The analysis was conducted in iterative steps:

1. **Initial coding (open coding):**
   The transcripts were reviewed to identify recurring statements and concepts (e.g., unplanned deliveries, congestion, missing information, space constraints, reactive planning, trust in AI, manual data issues).
2. **Theme of development (axial coding):**
   Codes were grouped into broader categories aligned with the thesis structure and research questions. Examples of higher-level themes include:
   a. Typical on-site logistics challenges (and consequences),
   b. Decision-making areas (layout/space, deliveries/time slots, resource coordination),
   c. current way of working (tools, information flows),
   d. AI potential use cases (documentation automation, forecasting, planning support, quality checking),
   e. Barriers and risks (data quality, digital maturity, resistance, accountability).
3. **Synthesis and interpretation:**
   Themes were compared across roles to identify similarities and differences and to build a structured understanding that directly answers the research questions. The thematic findings were then interpreted in relation to the literature review.

The analysis approach was chosen because it allows the thesis to produce a structured understanding of experiences and perspectives and to connect observed challenges to implementation needs and AI opportunities.

2.4 Ethical conduct

Since the study involves interviews, several ethical considerations were addressed:

- **Informed consent:** Interviewees were informed about the thesis topic and how their statements would be used. Participation was voluntary, and interviewees could withdraw at any time.
- **Confidentiality and anonymity:** Interview content is handled confidentially. Where needed, statements can be anonymized in the final report (role-based referencing rather than personal identification).
- **Recording and data handling:** Interviews were recorded only with consent. Recordings and transcripts are stored securely and used only for this thesis.
- **Respect for interviewees and organization:** Sensitive company/project details are treated carefully to avoid unintended disclosure.

2.5 Sustainability aspects

The thesis topic is connected to sustainability because improved on-site logistics can contribute to:

- Reduced waste from damaged or repeatedly handled materials,
- Fewer unnecessary transports and idling,
- Improved safety and reduced disruptions (which indirectly reduce inefficiencies and resource use),
- Better planning reliability, supporting more efficient use of equipment and time.

Although sustainability measurement is not the focus of this thesis, sustainability is relevant as a motivation for improving logistics and as a secondary effect of better planning and coordination.

2.6 Quality of the study

To ensure trustworthiness, the study quality is discussed through four commonly used qualitative criteria:

- **Credibility:** Strengthened by using multiple interviews across different roles and companies and comparing interview findings with literature.
- **Transferability:** The thesis is grounded in Swedish construction logistics practice and a real industry partner; results are most transferable to similar urban and multi-actor projects where logistics coordination is a challenge.
- **Dependability:** The interview guide structure, transcription process, and analysis steps are documented.

- **Confirmability:** The analysis aims to stay grounded in what interviewees stated and what literature supports.

Limitations include that the study is qualitative and case-based and does not attempt to quantify KPI improvements or test a specific AI tool in operation. Instead, the contribution is a structured understanding of where AI could support on-site logistics and what practical conditions are required for implementation.

3 Literature review

The main challenges of urban construction projects are limited space and access control, accessibility restrictions, and complex coordination between multiple actors. In such contexts, construction logistics is increasingly highlighted as an important deciding factor of project performance, since disturbances in material and information flows can quickly affect workflow stability on site (Janné, 2021; Forsemalm, 2023). Studies have also shown that delivery clustering, congestion, and coordination failures also occurred frequently in practice and that they have led to inefficiencies in construction production (Andersson & Nilsson, 2018; Sezer & Fredriksson, 2021). As a result, this chapter begins by reviewing research on on-site logistics and providing a foundation for discussing how AI-based decision support could be applied to improve on-site logistics planning and execution.

3.1 Construction logistics and on-site logistics

3.1.1 Definitions and system boundaries

Within the construction industry, the concept of logistics extends beyond transportation. Construction logistics includes planning, coordination, and controlling the flow of materials, equipment, and information across a variety of construction activities. This becomes especially critical in urban construction, where space limitations, access restrictions, and coordination among multiple actors strongly influence logistics performance (Janné, 2021; Forsemalm, 2023).

For analytical purposes, a distinction between off-site and on-site logistics was used in this thesis. Off-site logistics refers to activities outside the perimeter of the site (e.g., supplier coordination, transport planning, and external traffic arrangements). On-site logistics, which is the focus of this thesis, refers to logistics activities within and directly connected to the construction site, including delivery reception, unloading, temporary storage, internal transport, lifting and hoisting operations, and spatial coordination of materials and equipment on site (Andersson & Nilsson, 2018; Janné, 2021).

The importance of this boundary is emphasized by the fact that many logistics-related disturbances affecting production manifest on site through waiting time, congestion, re-planning, and inefficient material handling (Fredriksson et al., 2024; Sezer & Fredriksson, 2021). Beyond physical flows, on-site logistics also relies on information flows. Delivery bookings, updated site layouts, access restrictions, crane / hoist availability and short-term production plan all influence how smoothly logistics operations can be executed. Fragmented information exchange and weak coordination routines are challenges in complex projects with many subcontractors and changing site conditions (Bosch-Sijtsema & Sundquist, 2022; Fredriksson et al., 2024; Forsemalm, 2023).

3.1.2 Typical on-site logistics processes

Logistics involve a series of linked processes that must be maintained continuously in order to ensure a steady production flow. Although terminology and responsibilities may vary between projects and organizations, the literature consistently highlights several core processes that shape on-site logistics performance (Andersson & Nilsson, 2018; Janné, 2021; Sezer & Fredriksson, 2021).

a) Delivery planning and time-slot coordination

Delivery planning involves booking delivery times, coordinating arrival windows, and aligning deliveries with site readiness and production needs. Especially important during construction are peaks, caused by high or peak loads that, when added together, exceed the site's access and unloading capacity (Sezer & Fredriksson, 2021).

b) Receiving, unloading, and check-in procedures

Upon arrival of the materials or goods, the receiving process includes check-in of arrival, product verification, and then product receipt, either for temporary storage or direct use. Disturbances at this stage often occur when unloading zones are not prepared or when multiple deliveries arrive simultaneously, increasing waiting time and coordination pressure (Andersson & Nilsson, 2018; Janné, 2021)

c) Temporary storage and space management

While on-time delivery is certainly preferable, there are some unforeseen circumstances, where raw material deliveries and on-site operations often interfere with the achievement of the deadline, necessitating handling methods to the point of use which minimize disruptions. Storage management becomes a major planning challenge in urban projects where site areas are limited (Janné, 2021; Forsemalm, 2023).

d) Internal transport, distribution, and material handling

Internal logistics includes moving and distributing goods to various work areas, usually from storage area to the point of use.

e) Lifting and hoisting coordination

Cranes and hoists are shared and limited resources. Conflicts in crane/hoist use can trigger cascading delays across multiple trades if logistics and production plans are not synchronized (Andersson & Nilsson, 2018; Forsemalm, 2023).

f) Coordination of actors and information

On-site logistics is a coordination process involving multiple actors such as the main contractor, subcontractors, suppliers, drivers, and site management. Even well-designed logistics plans can fail if coordination and rule compliance between parties is weak (Janné, 2021; Janné & Rudberg, 2022).

3.1.3 Common challenges and root causes

Fragmented responsibilities and poor information flows are widely recognized as root causes of on-site logistics challenges, while congestion, waiting, and inefficient material handling represent their operational manifestations, particularly in urban construction contexts (Fredriksson et al., 2024; Janné, 2021; Forsemalm, 2023).

a) Fragmented responsibilities and information flows

Responsibilities are often distributed across temporary project organizations and multiple subcontractors, and information may be incomplete, inconsistent, or not shared in time to support coordination (Bosch-Sijtsema & Sundquist, 2022; Fredriksson et al., 2024; Janné & Rudberg, 2022).

b) Poor space utilisation and changing site conditions

Construction sites are dynamic environments in which available space is continuously altered as production advances. If layouts, storage zones and access routes are not updated and communicated effectively, logistics operations can interfere with both production activities and site safety (Andersson & Nilsson, 2018; Janné, 2021).

c) Congestion and delivery peaks

When deliveries cluster within limited time windows, queues form and turnaround times increase (Sezer & Fredriksson, 2021). In urban settings, these effects are further intensified by restricted site access and a scarcity of designated unloading zones (Janné, 2021; Forsemalm, 2023).

d) Waiting time and workflow interruptions

Uncoordinated deliveries, missing materials, or constrained crane and hoist access can each trigger waiting periods that subsequently generate ripple effects across multiple interdependent activities (Lindholm & Lundberg, 2022; Forsemalm, 2023).

e) Double handling and inefficient material flows

Materials often reach the point of use indirectly due to early deliveries, unclear storage planning or changed site conditions. As a result, handling time, handling costs and the risk of material damage all increase (Fredriksson et al., 2024; Lindholm & Lundberg, 2022).

3.1.4 Implications for this thesis

In summary, the literature reports repeated on-site logistics problems including congestion and waiting, double handling, conflicts in space utilization and failures of coordination, especially for urban and space-limited projects (Andersson & Nilsson, 2018; Janné, 2021; Sezer & Fredriksson, 2021). These problems are associated with repeated decisions in the face of uncertainty and changing conditions for site operations.

One approach for solving these problems is with AI-based decision support to provide forecasts, optimize and compare scenarios for space utilization and resource coordination. This provides a logical transition to the next section of the literature review and to AI concepts and applications for on-site construction logistics (Sezer & Fredriksson, 2021; Yang et al., 2024).

3.2 Performance impacts and KPIs of on-site logistics

3.2.1 Why on-site logistics matters for project performance

On-site logistics has a direct effect on the level of predictability and stability for production on construction sites. When processes for delivery receipt, storage and internal transport and lifting/hoisting are poorly integrated, disturbances spread to production activities and result in interruptions, replanning and lower levels of workflow stability (Andersson & Nilsson, 2018; Sezer & Fredriksson, 2021). For urban projects with limited space and access, the sensitivity to disturbances increases so that small deviations (e.g. a late delivery or blocked area for unloading) result in congestion and waiting and affect multiple trades simultaneously (Janné, 2021; Forsemalm, 2023).

A number of Swedish studies confirm that construction logistics should not be considered as a "support function" because decisions on logistics determine the conditions for production and thus influence time performance, cost development, safety and environmental impact (Janné, 2021; Forsemalm, 2023). In addition, conditions for deliveries and access to the site are major sources of variation for daily operations. For example, clustered deliveries during limited time windows produce queues and longer turnaround times that increase the coordination requirements and the risk for disruption of workflow (Sezer & Fredriksson, 2021).

These results confirm the focus of the thesis that improvements in on-site logistics produce value by reducing recurring disturbances and increasing the reliability of daily production.

3.2.2 Typical impact mechanisms

The literature describes several recurring mechanisms through which weak on-site logistics contributes to inefficiencies:

- **Waiting time and idle resources:** Crews may wait for materials, equipment access, or lifting capacity, especially when deliveries deviate from plans or when storage and unloading zones are congested (Lindholm & Lundberg, 2022; Sezer & Fredriksson, 2021).
- **Double handling and unnecessary movements:** When space is limited or storage planning is unclear, materials are placed temporarily and later moved again, increasing labour time and handling effort and potentially causing damage (Fredriksson et al., 2024; Lindholm & Lundberg, 2022).
- **Resource conflicts and bottlenecks:** Shared resources such as cranes and hoists can become bottlenecks when logistics and production are not

synchronised, creating delays that affect several trades (Andersson & Nilsson, 2018; Forsemalm, 2023).

- **Re-planning due to deviations:** Changes in site conditions, layout, or delivery timing can force reactive adjustments, increasing coordination work and reducing planning reliability (Fredriksson et al., 2024; Janné, 2021).

In urban conditions these mechanisms are amplified by external constraints including limited access routes and tight delivery time windows and therefore less capable of absorbing disruptions without impacting production (Janné, 2021; Forsemalm, 2023). In addition, they are directly associated with project delays in that cumulative waiting, re-handling and re-planning results in additional hours of labor and extended durations of activities. Over time these disruptions increase the risk of schedule delay and of higher indirect costs, in particular for projects with high interdependencies between trades and low capacity for on-site buffers (Andersson & Nilsson, 2018; Sezer & Fredriksson, 2021).

3.2.3 Safety and sustainability implications

On-site logistics is closely related to safety. Bottlenecks at access points, overloaded storage areas and frequent internal material movements increase exposure to accidents and unsafe interactions among workers, vehicles and lifting operations (Sezer & Fredriksson, 2021; Forsemalm, 2023). From a sustainability point of view, inefficient logistics leads to additional transports, less engine usage, wasted handling work and material losses and increases the environmental footprint of operations on site (Janné, 2021; Forsemalm, 2023). This thesis focuses primarily on improving workflow and providing decision support. This reinforces the argument that improved on-site logistics are strategically important for the construction industry.

3.2.4 Indicators for describing workflow efficiency in on-site logistics

Although performance measurement is not the main focus of the thesis, the literature suggests that certain practical indicators are useful for describing workflow efficiency and identifying where disturbances occur. Such indicators can also support the analysis of where AI-based decision support could create value (Andersson & Nilsson, 2018; Sezer & Fredriksson, 2021). Examples include:

- **Delivery reliability:** deviation between planned and actual delivery time; frequency of early/late/no-show deliveries (Sezer & Fredriksson, 2021).
- **Queueing and turnaround time:** waiting time at site access/gate and time spent from arrival to completion of unloading (Sezer & Fredriksson, 2021).
- **Handling intensity:** frequency of re-handling or number of internal moves before materials reach point of use (Fredriksson et al., 2024; Lindholm & Lundberg, 2022).
- **Space conflicts and congestion events:** occurrences where storage areas overflow, access routes are blocked, or unloading zones are unavailable (Janné, 2021; Forsemalm, 2023).

- **Crane/hoist availability conflicts:** cases where planned lifting cannot be executed due to scheduling conflicts or bottlenecks (Andersson & Nilsson, 2018). In addition to conflicts, the utilization of cranes and hoists (e.g., periods of underuse due to missing materials or overuse causing queues) can indicate how well logistics and production are synchronized. High utilization combined with frequent conflicts may indicate bottlenecks, while low utilization may reflect inefficiencies such as waiting for deliveries or poor coordination of lifting tasks (Andersson & Nilsson, 2018; Forsemalm, 2023).

In this thesis, such indicators are primarily used as a conceptual lens to structure interviews and case observations (e.g., “what disturbances are most common and why?”), rather than as a full performance-measurement study.

3.2.5 Implications for AI as decision support

The literature reviewed here reveals that many on-site logistics effects are due to repeated decisions under uncertainty including allocation of time windows, prioritization of deliveries, control of storage space and coordination of lifting resources.

In these areas, AI-based decision support may provide improvements in forecasting (e.g. risk of congestion or delay), facilitate optimization (e.g. allocation of scarce space and time windows) and enable decisions based on scenarios when on-site conditions change (Sezer & Fredriksson, 2021; Yang et al., 2024).

In addition, according to studies in Sweden on information flows and organizational readiness, the decision support achieved depends on accurate data collection, coordinated routines and well-defined responsibilities for actors (Bosch-Sijtsema & Sundquist, 2022; Fredriksson et al., 2024; Haglund, 2024).

3.3 AI use in construction

The following chapter gives a general overview of the term Artificial Intelligence (AI) in connection with the construction industry and the usage in the construction logistics sector.

3.3.1 Introduction to Artificial Intelligence

The term “Artificial Intelligence” (AI) describes a multidisciplinary field of computer science with a focus on the development of systems with human-like intelligence which are capable of reasoning, problem-solving, and decision-making. A defining feature of AI is its ability to learn from data rather than relying on explicit instructions for every individual task. It can identify patterns, organize unstructured information and create synthetic content. In recent times, AI functions as an intelligent agent who perceives its environment and making autonomous decisions as well as carrying out actions based on those decisions (Datta et al., 2024; Gehring et al., 2025).

The field is categorized into three primary levels: Artificial Narrow Intelligence (ANI), which is limited to specific domains like language translation, weather forecast or playing chess. Artificial General Intelligence (AGI), which seeks to perform tasks with human-like abilities across various domains. It can control itself autonomously and is able to have its own thoughts, worries and feelings as well as strengths and weaknesses. And lastly, Artificial Super Intelligence (ASI), which would surpass human capabilities across all domains (Abioye et al., 2021; Datta et al., 2024).

Fundamentally, artificial intelligence consists of knowledge representation, learning, perception, action, planning, and communication. After the implementation of AI in several other industries, different subfields have emerged. Some of those subfields being Optimization, Natural Language Processing, Automated Planning and Scheduling, Robotics and Machine Learning (Datta et al., 2024).

3.3.2 Artificial intelligence in the construction industry

The implementation of Artificial Intelligence (AI) and Machine Learning (ML) in the construction industry represents a shift from manual, labor-intensive practices to data-driven, autonomous systems designed to optimize the entire project lifecycle (Zhang et al., 2024). While the industry has historically been slow to adopt digital technologies, recent years have seen a significant increase in AI research and application, particularly since 2015 (Fig. 1), driven by the rise of Industry 4.0 and the need to address challenges like labor shortages, cost overruns, and safety risks. This has led to an improvement in business operation and industry productivity. Research on areas such as optimization, machine learning and robotics have been of major interest in the past decade (Abioye et al., 2021).

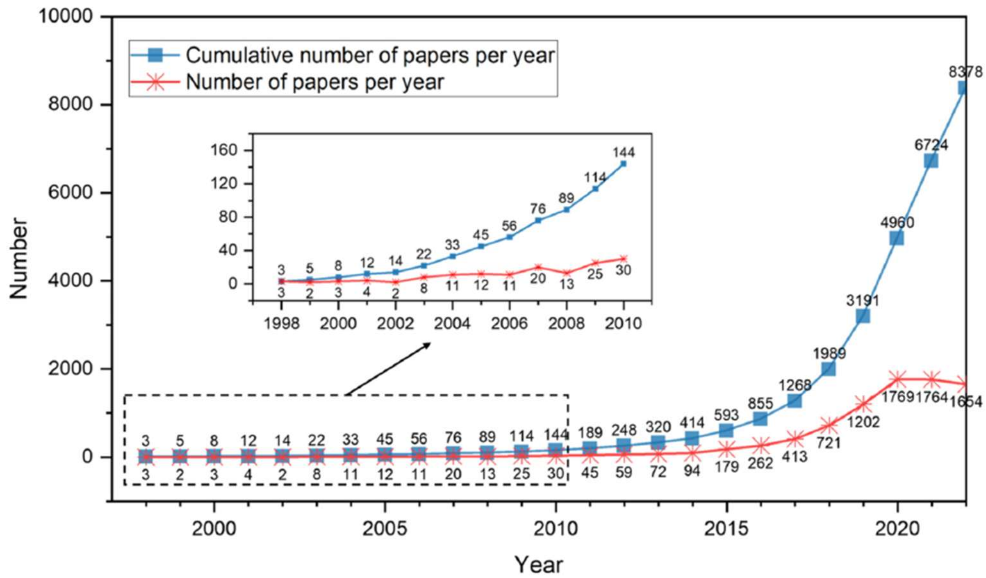

Figure 1: Annual number of publications about intelligent construction (Zhang et al., 2024)

Modern construction projects utilize AI across different functional areas to enhance efficiency and quality. During the planning and design phases, AI techniques such as generative design allows engineers to quickly explore multiple design alternatives based on specific parameters, constraints and expert knowledge. Furthermore, the use of ML models in early projects stages can predict project costs and durations with 91%

to 97% accuracy. In addition to that, ML is used for predicting risks, monitoring health and safety and improving supply chain and logistics processes. Building Information Modeling (BIM) functions as an essential data source which AI applications can use for model checking and clash detection between the building structure and installation systems. (Datta et al., 2024; Elmousalami et al., 2025; Zhang et al., 2024).

During execution and construction, robotics and autonomous systems are increasingly used for repetitive and dangerous tasks, including bricklaying, rebar tying, demolition and 3D printing of complex shapes. The use of robotics can counteract labour shortages and reduce operating expenses while increasing and guaranteeing quality, accuracy and security. Unmanned Aerial Vehicles (UAVs) or drones, equipped with computer vision, conduct land surveying, monitor site progress and identify structural defects through remote laser scanning. Smart Construction Safety is a major focus, utilizing predictive analytics to identify hazards and wearable devices, such as EEG helmets, to monitor worker fatigue and prevent accidents. In the Operations and Maintenance phase, Digital Twins, that act as virtual replicas of physical assets, integrate Internet of Things (IoT) sensor data with AI to provide real-time monitoring, predictive maintenance, and energy management for systems like HVAC (Datta et al., 2024; Elmousalami et al., 2025).

3.3.3 AI and Machine Learning in On-site Construction Logistics

The construction logistics sector in particular is being revolutionized by AI through the integration of information, material, and economic flows (Kifokeris & Koch, 2020). A primary application is the development of AI-enabled scheduling platforms (such as ConLogAI) that utilize BIM data to automate the generation of delivery packages, installation timelines, and resource allocation plans. These systems aim to minimize project duration while simultaneously reducing on-site inventory levels and the total number of required deliveries. More precisely, ConLogAI generates schedules directly from building data instead of relying on predefined activity lists. As shown in Figure 2, the process starts with the extraction of components (currently focused on windows and doors) from IFC models. Then, AI-driven semantic enrichment is applied to classify elements, determine necessary tasks and establish dependencies. The system uses optimization techniques, such as Particle Swarm Optimization (PSO) or AI-based scheduling agents, to solve the Resource-Constrained Project Scheduling Problem. This process transforms raw task data into structured execution, delivery and installation schedules. However, this tool has been only used for two components (windows and doors) which limits the generalizability across diverse construction scenarios. Furthermore, the lack of empirical data, the high complexity of AI models and Reinforcement Learning, and the need for computational infrastructure and high-quality data pose as hurdles and challenges to implement such tools at the current stage (Gehring et al., 2025).

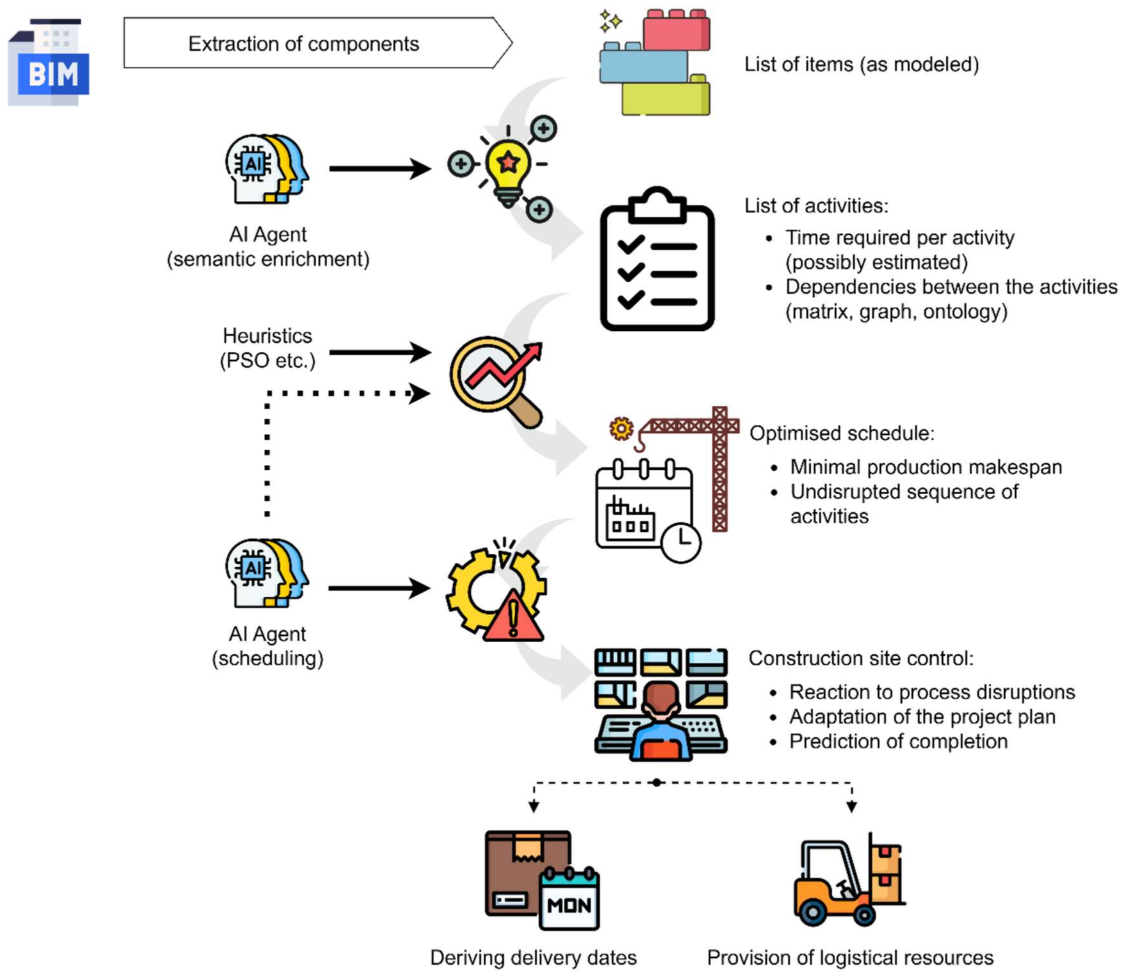

Figure 2: Workflow of AI-enabled scheduling platform (Gehring et al., 2025)

Supply chain management utilizes AI and Blockchain to create transparent, decentralized systems for tracking materials and verifying transactions. A case study mentioned by Lanko et al. (2018) showed that the combination of RFID (Radio Frequency Identification) and blockchain can be used to track the delivery of ready-mixed concrete in real-time, accurately predicting arrival times and preventing data errors caused by the human factor. Furthermore, it can amplify trust between supplier/manufacturer and participants of the construction process through increased transparency about delivery times and information flows. Suppliers and manufacturers that implement those technologies can use this increased trust and gain an advantage over their competitors (Abioye et al., 2021; Lanko et al., 2018).

Logistics optimization can also extend to specialized equipment management. AI frameworks that utilize artificial neural networks (ANN) and heuristic search are currently developed to select optimum crane configurations for heavy industrial projects. By considering weights, dimensions and safety parameters, cost overruns and delays can be prevented (Azami et al., 2022).

Designing an efficient site layout is an essential part of on-site logistics planning. It involves balancing conflicting goals, such as minimizing handling costs while maximizing safety. Decision-making systems use Ant Colony Optimization (ACO) algorithms to search for optimal arrangements of temporary facilities like storage areas and site offices. These algorithms simulate the behavior of ant colonies to find the most efficient "paths" or layouts through iterative digital searches. To handle the dynamic nature of construction, one of the applied schemes (Continuous Dynamic Searching Scheme) divides the project into phases. Facilities that are needed across multiple phases are "fixed" in their locations once they have been assigned in an earlier phase. This technique could prevent unnecessary facility moves, avoid double handling costs and increase productivity as the project progresses. During a case study for a multi-story residential building in Beijing, China, this system successfully generated several optimized layout alternatives, demonstrating that the proposed approach could reduce the likelihood of accidents by up to 18.4% and handling costs by up to 27.2% compared to original, non-optimized plans (Ning et al., 2011).

Reinforcement Learning (RL) and Deep Reinforcement Learning (DRL) have proven to be powerful approaches for dynamic scheduling and resource optimization in project management, particularly in complex and uncertain construction environments. Unlike traditional scheduling methods, these approaches continuously adapt to real-time conditions by learning through interaction with the project environment. RL models optimize decision-making by receiving feedback in the form of rewards connected to performance metrics such as delay minimization and resource utilization. The integration of deep neural networks in DRL further enhances this capability which is enabling the processing of high-dimensional data and making it well-suited for large-scale projects with numerous interdependent tasks and constraints. As a result, these methods can dynamically optimize task sequencing, resource allocation, and scheduling adjustments, leading to more robust and resilient project outcomes (Elmousalami et al., 2025).

In addition to scheduling, RL and DRL play a critical role in improving resource allocation strategies. These methods use an iterative process to evaluate different allocation decisions, which is optimising the use of personnel, equipment and materials based on cost, time and availability. DRL systems, in particular, use both historical data and real-time inputs to predict and adapt to changing resource demands, which can reduce bottlenecks and improve overall efficiency. These techniques are essential for Project Management Automation (PMA) because they support data-driven decision-making and reduce the need for manual intervention. This can further increase the efficiency and resilience of project execution.

3.3.4 Barriers for AI adoption in construction logistics

Despite its potential in the construction industry, particularly on-site, AI faces various challenges and barriers to adoption in daily practice. In most cases, these result from a combination of cultural, technical, financial, and regulatory domains.

Cultural and technical barriers

Besides the industry being slow and resistant to adopting new technologies, the decision-making processes of most AI applications and machine learning systems are incomprehensible to the user. This "black box" effect prevents practitioners from fully trusting the processes and outcomes of these tools, which raises skepticism towards them. To address this issue, explainable AI (XAI) is being developed to create models that are more understandable, trustworthy and easier to manage (Abioye et al., 2021; Elmousalami et al., 2025).

Another challenge for AI implementation is the fragmented workflows in the industry. Various stakeholders use different software systems, creating "information silos" or "information islands", where data is stored in incompatible systems, making it difficult for AI systems to access and use. Closely connected to this are the confidentiality requirements that most engineering projects have. Many firms are reluctant to share data due to intellectual property protection and confidentiality requirements, which limits the availability of the large datasets needed to train AI. Especially historical data would be highly relevant to learn from previous projects and train AI models for future projects (Elmousalami et al., 2025; Zhang et al., 2024). Furthermore, AI models require high-quality datasets, which are often scarce in the construction industry. Real-world site data is often unstructured, incomplete or inaccurate, which shows a need for more accurate data collection and processing (Elmousalami et al., 2025; Gehring et al., 2025).

Financial and Workforce Challenges

Integrating AI usually requires significant upfront investments in infrastructure, hardware and software, which can be particularly unaffordable for smaller or mid-sized firms and subcontractors. Costs for training and the fact that workers won't be available during training can also be a barrier to implementing new technologies. Furthermore, AI engineers who have sufficient knowledge of and experience in the construction industry are limited (Abioye et al., 2021; Elmousalami et al., 2025).

Legal and Regulatory Issues

When it comes to legal and regulatory issues surrounding the use of AI in construction, it is apparent that there is no unified set of standards or legal precedents to guide its implementation. Furthermore, increased digitalization makes projects vulnerable to cybersecurity risks, such as cyberattacks, data breaches and malware, which could compromise sensitive intellectual property (Elmousalami et al., 2025; Wijayasekera et al., 2022).

4 Results

This chapter will summarize the results and findings of the interviews that have been conducted with multiple people involved in on-site logistics. It will give an overview of their perception of common challenges in their field of work and their view on possible AI solutions for those problems as well as a general view on AI in the construction industry.

4.1 Challenges and consequences

The interviews reveal a consistent set of challenges in on-site construction logistics which are primarily resulting from a lack of proactive planning, fragmented information flows, and strong cultural resistance within the industry. A central issue across all respondents is that logistics are not prioritized enough in early project stages and is instead handled reactively. One interviewee emphasizes that there is a “lack of planning and understanding the importance of planning ahead,” and that “it’s not in the business DNA to solve logistic problems ahead”. This observation is reinforced by another respondent, who blames many operational issues on “insufficient planning/logistics design before project start”, while a logistics manager on-site describes situations of “non-existing planning” and decisions being made very late in the process. Together, these perspectives indicate a tendency towards reactive problem-solving instead of proactive logistics design.

A logistics manager responsible for on-site logistics for a large subway station and tunnel construction project described that logistics is still considered a "new" discipline for the construction industry and requires constant reminders and reinforcement of established procedures. For each project, a logistics plan was developed with specific rules to follow, but adherence generally required continuous follow-up because most construction workers preferred to continue performing their tasks "in the manner to which they have always been accustomed."

This tendency to reactive response is also closely related to the ways in which deliveries and daily coordination are carried out in practice. A logistics project engineer with 12 years of experience reinforced this theme by noting that most projects "plan a little" and then proceed on the assumption that they will "solve it as it comes up." He stressed that logistics planning must begin and be completed before site start, because conditions on the job change substantially throughout the project and must continue to develop over time. Finally, he described how efforts to maintain major elements (e.g., sheds, gates, fences) in the same location for as long as possible would reduce rework and achieve large savings in project costs.

A project manager for logistics at Bygglogistik (responsible for several ongoing projects and for logistics personnel) described logistics as generally reactive because it is not emphasized in the early stages of a project. He also pointed out that although plans are developed, time pressures and changing conditions restrict the extent of planning achieved and thereby reinforce reactive modes of problem-solving.

A logistics consultant with substantial experience with major Swedish projects noted that reactive logistics typically reflects uncertainty about delivery times. Deliveries are usually planned only as "morning" or "afternoon" rather than at a specific time and require reactive responses to arrivals of trucks. This results in interference with other operations when resources must be diverted from other tasks, or when materials impede access to areas for unloading.

Another interview confirmed this trend by mentioning problems of inadequate preparation and poorly defined routines for planning, reporting, and coordination of construction activities. The interviewee emphasized that most projects fail to recognize the potential for efficiency that comes with logistics preparation and the importance of logistics problems that result from inadequate preparation.

Another interviewee described one reason why this continues: logistics is generally not viewed as a separate discipline at the time of planning and budgeting for a project. She compared logistics to other engineering "disciplines" included in initial plans and budgets and contended that because logistics is not always treated as an independent discipline, budgets and hours for it are not allocated for most projects. Consequently, logistics is generally implemented only after physical construction has begun on site at a time when costs are higher, and alternatives are more limited.

Closely linked to this is the problem of poor information flow and communication between project stakeholders. Several interviewees highlight that information is often incomplete, delayed, or not shared effectively among the many actors involved. For instance, one respondent explains that the person receiving deliveries frequently “doesn’t know what is coming” and therefore requires additional effort to collect and consolidate information from multiple sources. Similarly, another interviewee notes that “information doesn’t reach everyone doing the work”, particularly in projects involving a large number of subcontractors. In the largest projects, several actors depend on the same delivery information (gate personnel, unloading resources, and site management), and when information is missing or not updated, the entire delivery process becomes more reactive.

A logistics coordinator on a high-security prison construction site described how logistics management becomes particularly vulnerable to gaps in information because access to the site requires stringent approvals. The major daily task is to obtain timely and accurate information on the vehicle and driver expected to arrive, as pre-employment checks must be completed and approvals frequently are submitted only the day before. Additional difficulties associated with multiple gates and long delivery times required careful coordination of routing and access in a highly restricted environment.

This experience also illustrated barriers to communication resulting from requirements for security clearance: Most construction workers were prohibited from having telephones, resulting in difficulty with rapid communication of changes and with clarification of patterns of information flow on the project.

One project manager also characterized this problem as an internal issue with the project: Even within the same main contractor organization, different work packages and supervisors can become so preoccupied with their own schedules and scopes that interdependencies among work packages become a common problem. Importantly, logistics activities often generate value by identifying such overlaps at an early stage (e.g., when two activities require the same gate, space or time window), thereby allowing conflicts to be resolved before they arise.

The same consultant noted that this degree of information fragmentation is exacerbated when numerous actors require access to identical delivery information (e.g., gate personnel, equipment for unloading, and site management). Although tools for planning deliveries are available, the major difficulty remains in providing access to current, up-to-date information for all who require it.

One interviewee emphasized the industry's lack of transparency and measurement of productivity that hinder continuous improvement. The interviewee compared construction with manufacturing in which detailed data on productivity leads to learning and incremental improvement. Most measurements in construction instead reflect primarily financial performance (and to a limited extent, quality) rather than productivity in a manner that develops a "learning platform" over time.

Ultimately, these deficiencies in planning and communication result in unreliable and poorly prepared deliveries. Common issues include deliveries arriving at incorrect times, with incorrect materials, or using unsuitable vehicles which in turn create queues, waiting times, and disruptions on-site. At the same time, construction sites are characterized by significant spatial constraints and constantly changing conditions. Limited space, combined with late planning decisions, makes it difficult to allocate storage areas or develop alternative logistics strategies. Planning is further complicated by external constraints such as surrounding traffic, nearby residents, and fixed access points, all of which must be considered in logistics design.

In the same interview, daily problems associated with transportation routes and unloading operations were described in detail. The interviewee emphasized that planning of gates and routes is inadequate alone, because different types of vehicles require different methods of unloading, must be coordinated with methods of placing stored materials, and must conform to limitations on methods of lifting. In addition, it was stressed that safety for workers and for members of the public must be incorporated into all aspects of logistics planning, especially for projects located in urban settings with conventional traffic and large numbers of pedestrians and cyclists.

The Stockholm subway project illustrated well the effect of limited space on logistic pressures. Storage was identified by the logistic manager as one of the major problems of a central city location. Supervisors encouraged subcontractors to order large quantities to the site, and logistic efforts were directed toward a goal of just-in-time ordering "for the week." Loss of external capacity because of cost further increased demands on space, trucks and capacity for handling materials.

In addition to limitations on storage capacity, the same interview illustrated waste associated with late design changes. The logistics manager cited instances in which materials had been ordered and subsequently deleted from drawings as a result of revised designs, leading to surplus items that could not be used and occasionally had to be discarded.

The delivery planner also described that the site had previously experienced severe problems of missing materials ("everything disappeared") with goods distributed throughout the site and no overall visibility. This situation was improved by modifying the logistics configuration to provide centralized handling at a staging area, where responsibility for delivery of materials to appropriate recipients on site was assumed by logistics personnel. Drivers could not be expected to deliver correctly in a complex and unfamiliar setting, and centralized handling reduced time required for search of materials.

In addition, interviewees reported persistent problems with accumulation and storage of materials. One consultant noted that sites generally receive more materials than can be consumed immediately and thereby become sites of storage. This results in excessive amounts of handling, risk of loss and damage and requirements for internal transportation and coordination.

An additional effect of the lack of planning for storage areas and material placement was the development of unorganized sites. Examples included closure of public roads for unloading of materials (often without permits when deliveries were unexpected), absence of safe pedestrian access in areas where loaders and vehicles operated, and inadequate planning for delivery and disposal of waste resulting in excessive congestion, broken pallets and accumulation of leftover materials throughout the site.

Another interviewee pointed out that construction logistics must be viewed as more than on-site activities. On-site logistics represent an important but relatively small component of the overall logistics system. Effective on-site logistics depend critically on previous planning and integration with the supply chain. This represents a "pacing" problem in which construction uses materials in small batches, but upstream suppliers provide materials in large batches instead. Consequently, it is difficult to avoid shortages or to prevent an oversupply of materials from being delivered to and stored at the construction site, unless this mismatch in the timing of material deliveries is controlled throughout the entire supply chain.

One example demonstrated that project personnel typically fail to convert quantities of material to quantities of transport, resulting in unexpected peaks of delivery (i.e., multiple trucks arriving where one had been expected). The project representative observed that projects achieve substantially better planning for quantities of transport when they are space-constrained, because limitations promote earlier and more rigorous planning.

In addition, the fragmentation of responsibilities increases these problems: Responsibilities are distributed among several contractors with their own equipment (e.g., lifts), and result in increased risk of "flooding" the site with equipment and reduction of efficiency. The degree of excess material stored on site further reduced efficiency and worsened space limitations.

Another critical challenge is the resistance to creating change in the industry and the misalignment between stakeholders. Interviewees repeatedly point out that many actors in the construction industry prefer to rely on established practices, with one respondent stating that companies often “do as they always done”. This resistance extends even to basic digital tools, shown by the remark that some practitioners still rely on simple methods such as whiteboards for planning. In addition, clients may insist on their own preferred logistics solutions, even when alternative approaches are proposed, which often leads to compromised outcomes.

The logistics manager documented concrete effects of resistance to logistics routines: In some instances, construction workers continued to handle materials themselves despite planned logistics shifts that were to perform these functions. This resulted in "double work," with parallel performance of the same tasks by both the logistics personnel and construction workers, and with associated economic inefficiencies and disruption of planned logistics operations.

The consultant also noted that one difficulty in implementing digital planning tools is that the most widely used "system" for planning in practice remains a physical white board. Implementation of digital calendars for project delivery may thus increase rather than eliminate administrative requirements and further impede efforts to achieve acceptance.

One interviewee generated additional explanations for the continued use of fragmented and reactive approaches. Historical and structural forces included a severe decline in the construction industry in the early 1990s which resulted in job losses and a loss of experienced workers. This was followed by the development of internet-based order entry systems and shorter supplier lead times. This resulted in reduced perceived requirements for planning and greater opportunities for ad-hoc behaviour but also produced new problems of coordination and utilization of resources. The shorter lead times reduced demands for planning and facilitated more ad-hoc modes of operations.

The consequences of these challenges include increased project costs and durations, reduced safety, poorer working conditions, and negative impacts on surrounding environments. Inefficient logistics leads to double handling of materials, difficulties in locating goods, and increased risk of damage. Furthermore, the resulting stress and time pressure contribute to unsafe working conditions and a higher likelihood of accidents. Low levels of transparency and limited measures of productivity hinder systematic learning from projects and the achievement of continuous improvement. As a result, persistent inefficiencies across projects are reinforced, rather than overcome.

4.2 Application of AI in construction logistics

Against these challenges and issues, all interviewees express a generally positive attitude toward the potential of artificial intelligence (AI) in construction logistics while also maintaining realistic expectations regarding its role. One respondent explicitly states, “I believe it will solve a lot of problems”, while another notes that AI can “help a lot,” although it cannot replace human expertise. Overall, AI is consistently framed as a supportive tool rather than a substitute for professional judgment.

A key area where AI is expected to add value is in data integration and structuring. Given the fragmented nature of information in construction projects, AI could help “collect data from different sources and structure them” to provide a clearer overview. Similarly, it could analyze and summarize patterns across projects, enabling better decision-making and providing evidence of the benefits of improved logistics practices. In this sense, AI is seen as a tool to transform unstructured and inconsistent data into usable insights.

A CTO of a company providing logistics systems for construction sites indicated that, at present, AI is not integrated directly into their construction logistics product. Rather, AI is primarily used internally to accelerate development and shorten lead times for new functionality. The result, he said, is that most construction logistics projects are short, and conventional practice required delivery of a requested feature only after completion of the project. With AI-assisted development, they were able to develop and implement features rapidly enough to provide functionality within project time limits.

The same interviewee described use of AI throughout the entire internal workflow, from interpretation of customer requests and generation of technical specifications to production of code and testing, with "human-in-the-loop" quality control prior to delivery to customers.

The CTO also highlighted that the company avoids using customer data for AI training in accordance with requirements for privacy and security. This was achieved with rigorous "container" strategies that prevented access to sensitive information about customers and resulted in concern regarding the "black-box" nature of AI in applications involving customer data.

Although the field is still in an early stage and AI is currently used very little in daily work, the logistics engineer presented several realistic applications. Use of AI for decisions on gate design was one example, in which selected gate widths would provide optimal compromise among cost and space requirements and requirements for turning radius and maneuverability. In addition, recommendations for selection and location of cranes would be generated, provided adequate information on building geometry and requirements for lifting operations were available. Other applications included comparison of several versions of an APD plan to identify omitted objects or inconsistencies, and support for routing in which AI evaluated requirements for curvature and feasibility for a particular truck between pairs of locations.

One interviewee provides a concrete example of emerging AI-supported planning. Their company uses a mandatory delivery/logistics calendar configured per project (gates, unloading zones, resources) and linked to the APD plan. Furthermore, they are testing AI features that assess the upcoming plan and flag safety risks and capacity limitations, highlight overloaded days, suggest the need for additional capacity, and flag planned deliveries that did not occur and require follow-up.

Another interviewee illustrated an example of relatively high levels of AI adoption. The interviewee described extensive use of AI for various operations, including activities of software development (e.g., design of prototypes, specification of requirements, coding and testing) and of consulting work (e.g., extraction of information from large volumes of text and preparation of presentations). Achievement of this level of AI use required time and preparation, with an estimated investment of approximately eight months to develop infrastructure and procedures for AI use. The result was large improvements in efficiency (i.e., substantial reductions in time for many tasks and an overall reduction of approximately 50 to 60%).

Another important application area is planning and decision support. Interviewees suggest that AI could assist in automating parts of logistics planning, generating alternative layout options, and enabling faster replanning in response to change conditions. For example, AI could provide a "second opinion" by proposing different site layout configurations or supporting rapid development of alternate plans when disruptions occur. However, it is emphasized that such outputs must always be reviewed and validated by experienced professionals.

When asked about AI potential, the delivery planner described potential uses for calculating and forecasting flows into the site and for detecting potential conflicts in advance. However, he also expressed a lack of personal experience with AI tools and noted that AI can appear to be highly abstract to practitioners who have not applied the technology directly.

The project manager described additional applications for decision support related to on-site operations, including automated data collection with cameras at entry points to record vehicle type, registration number and times of entry and exit; AI-based identification of potential conflicts in APD plans more rapidly than manual methods; and improvements in traffic flow such as alerts to delivery planners of effects of peak-hour traffic and identification of conditions likely to produce traffic congestion. He noted that the number of potential applications is large, but that most require first development of a system for reliable data collection.

High-level AI-based layout and APD design are feasible in principle but restricted by the lack of qualitative data (e.g., vehicle types, requirements for manoeuvring and detailed characteristics for delivery). The interviewee illustrated the disparity between BIM representations in which building components are already installed, and with actual conditions for delivery and handling prior to installation.

In addition, there is a strong agreement among the interviewees that AI should initially be applied to the automation of routine and repetitive tasks. Suggested use cases include generating standard logistics documents, assisting with booking processes and handling administrative tasks that are described as “boring” but time-consuming. Automating these activities would free up time for more complex tasks requiring human judgment, such as creative problem-solving and site-specific planning.

AI is also seen as having potential in quality control and error detection. For instance, it could be used to check drawings for inconsistencies, identify overlooked mistakes, and compare different versions of documents to ensure accuracy. Furthermore, it could contribute to improving logistics operations by optimizing delivery scheduling, reducing manual data entry, and enhancing coordination between project participants. Some interviewees also highlight its potential to improve communication by collecting and distributing relevant information more efficiently across all stakeholders.

A concrete example of a low-technology but labor-intensive coordination problem was presented. Positioning a pallet at an exact location required numerous telephone calls and steps to provide explanations. The participant estimated that use of a simple map-based mode of communication (e.g., indicating a location on a site map and transmitting that information directly to the responsible loader operator) would reduce friction and predict that a future AI-based workflow would further simplify these procedures.

Despite this optimism, several significant barriers to AI adoption are identified. A major issue is the low level of digital maturity in the construction industry, where traditional tools and communication methods, such as phone calls, are still dominating. Data quality and availability are also critical challenges since much of the information required for AI applications is manually entered and therefore prone to errors which can lead to the risk of incorrect AI-generated recommendations. In addition, there is a lack of knowledge regarding the available AI tools and how to use them effectively. The general tendency to maintain established practices, which makes it easier for organizations to continue as they do, also makes it difficult to adopt new AI technologies.

The delivery planner described that data quality problems are partly caused by the high variability of construction work: needs change quickly, unexpected situations arise, and workers do not always know what will happen until the problem appears. The interviewee contrasted this with manufacturing-like settings where processes and resources are more standardized.

Additional limitations were identified with respect to the highly contextual nature of construction logistics and its difficulty of "standardization" for AI. The interviewee pointed out that human behavior and local conditions (e.g., actual pedestrian and bicycle behaviors and responses to disrupted routes) are factors that professionals incorporate intuitively, but that may not be captured by AI. Furthermore, restrictions imposed by regulations and changing rights of access (e.g., to areas that subsequently must be restored to the city) were difficult to translate into an AI format. Finally, practical difficulties of "teaching" AI and of requiring multiple iterations of rewording prompts to achieve results comparable to those of manual operations under time constraints, resulted in an overall process that was slower than conventional methods.

One consultant emphasized that limited AI adoption is not only about data sharing but also about data collection: many projects do not systematically collect high-quality logistics data or transfer it across projects. Incentives are often project-based, and site managers are evaluated mainly on cost outcomes and safety performance, which reduces motivation to invest in data capture for future learning or AI training.

It was pointed out that logistics transcends project phases and organizational boundaries, starting with tendering and contracting, continuing through design and construction and encompassing procurement, information management and physical flows. As a result, implementation is more difficult because uniform procedures, expectations, and levels of compliance are required for many participants.

Another interviewee revealed additional implementation barriers that are especially relevant when AI is incorporated into professional tools and platforms, including requirements for compliance with cybersecurity standards, maintenance of data integrity and protection of intellectual property. The interviewee emphasized that cybersecurity concerns were of primary importance to clients, and required implementation of secure configurations (e.g., "sandbox" methods) to prevent inadvertent disclosure of intellectual property while using AI-based tools and to maintain the reliability and compliance of system outputs.

From the perspective of the software-provider, risks and barriers were discussed in greater detail with reference to information security. The CTO described the use of formal risk analysis techniques to evaluate AI adoption and provided examples of specific risks, including "prompt injection" in which hidden instructions on a web page cause an AI tool to behave in unintended ways. Finally, the importance of "caging" AI tools within controlled environments to minimize these risks was stressed.

In addition to identifying information and technical risks associated with project delivery, the delivery planner also identified security risks: AI could propagate information that should not be accessible outside the facility and was especially critical for facilities classified for safety reasons.

The project manager also described limitations associated with privacy and security for expanded data collection (e.g., video surveillance at gates). Concerns about data attributable to individuals reinforced the need to determine what should be measured and at which levels of aggregation. Finally, the risk of dependence is emphasized: When organizations develop extensive work flows around AI-based systems, they may be at risk of failure to operate effectively in situations where use of AI is not possible (e.g., for highly sensitive projects) or when operations must be converted to analog methods because of incidents of information security or other disruptions of society.

Given these constraints, interviewees consistently recommend a gradual and pragmatic approach to AI implementation. Rather than attempting large-scale transformations, organizations should begin with small, low-risk applications that deliver clear value, such as automating repetitive tasks or supporting basic planning functions. As data quality improves and users become more familiar with AI tools, more advanced applications can be introduced over time.

The delivery planner emphasized that the successful adoption of solutions requires solutions that are rapid and easy to learn and produce immediate results. When users perceive a benefit, resistance decreases, but with slow learning, acceptance is more difficult.

From a market viewpoint, clients are generally favorable to AI but strongly emphasize cybersecurity assurance and perceived benefits of reliability, speed and cost savings. Consequently, acceptance will depend on demonstrating compliance with requirements and providing measurable benefits, not on promoting AI as an independent innovation.

In summary, the findings suggest that the main challenges in on-site construction logistics are organizational and cultural rather than technological. Although AI is widely regarded as a promising tool for addressing issues related to data management, planning and coordination, its successful implementation will depend on improvements in digital maturity, data quality, and stakeholder collaboration. Ultimately, AI is expected to play a supportive role by enhancing human decision-making rather than replacing it, and its impact will depend on broader changes within the construction industry.

5 Discussion

This chapter interprets and discusses the empirical results reported in Chapter 4 in the context of the theoretical perspectives and prior research described in Chapter 3. The objective is to explain why particular patterns emerge, how they can be integrated into a broader perspective of construction logistics, and what they imply for the research questions of the thesis. The results are organized in response to the research questions.

5.1 Most common on-site logistics challenges

The difficulties described across interviews are remarkably consistent despite variations in roles (strategic, planning, and on-site implementation). The basic pattern is that on-site problems generally arise not from an isolated cause, but because of interactions among:

- Late and reactive planning
- Poor integration of information among many actors
- Limitations on space and resources that increase variability

This supports the view of on-site logistics as a dynamic system of production support for which performance depends on quality of planning, procedures for coordination and effective modes of information transfer, especially for complex and urban projects.

5.1.1 Reactive planning and late logistics involvement

A major empirical result is that logistics is often not given sufficient priority to be proactive but instead becomes reactive. Interviewees described logistics as a problem-solving activity which is initiated only after difficulties arise, instead of integrating it proactively as a design activity into the production system. This confirms findings of Swedish research on construction logistics indicating that logistics planning generally begins too late in the project cycle to produce proactive material flows or operating procedures. The results also illustrate why this is important: Late project planning eliminates the opportunity to develop viable alternatives (e.g., buffers or "Plan B" solutions), and increases the amount of re-planning, congestion and time pressures.

Reactive logistics can be interpreted not only as operational behaviour, but also as a result of organisational conditions. Responsibilities for logistics activities were largely distributed to subcontractors, where the primary contractor or logistics department provides overall coordination and control without complete responsibility for logistics activities.

5.1.2 Fragmented information flows and coordination failures

A second major challenge is related to information flow. Multiple respondents described situations in which information was incomplete, delayed or not received by individuals working on site. Examples included ignorance of what was to arrive or failure to provide information to all personnel of multiple subcontractors. This is consistent with the literature which links disruption and inefficiency primarily to fragmented information flows. This highlights the practical importance of poor communication in causing variability in delivery times, as well as delays and disruptions on site.

The continued occurrence of these problems despite the availability of digital tools provides an additional explanation for the difficulty of achieving effective logistics operations on site. In most cases, planning tools for deliveries still requires manual input and frequent updating. Avoiding "double work" by failing to transfer information from procurement systems to delivery calendars resulted in gaps in information and a loss of confidence in the system. This further illustrates the general importance of developing and maintaining routine systems of integration that provide a reliable basis for an overall understanding of future deliveries and conditions for effective operations on site. Finally, it supports again the importance of applying principles of coordination and information control to achieve effective logistics operations on site.

These results support the conceptual framework from the literature review, in which on-site logistics is viewed as a production-support system requiring early planning and systematic coordination rather than ad-hoc problem-solving (Andersson & Nilsson, 2018; Janné, 2021; Sezer et al., 2021). Importantly, they confirm that performance on-site is achieved only to the extent that deliveries, unloading, internal transport, lifting, hoisting and allocation are coordinated dynamically, and that delays in planning substantially increase the likelihood of subsequent re-planning and disruptions of integrated work processes (Andersson & Nilsson, 2018; Janné, 2021; Sezer et al., 2021). The pattern of fragmented responsibilities among subcontractors and of inconsistent flows of information also is consistent with the interpretation of extensive problems with systems of diffuse accountability and inadequate integration of information as the major causes of chronic disturbances in on-site logistics (Bosch-Sijtsema & Sundquist, 2022; Fredriksson, 2024). Finally, the dominance of reactive control and limitations on the capacity for ad hoc responses confirms the previous findings regarding urban and spatially restricted projects, where minor delays quickly led to congestion, idle time, and the disruption of integrated work processes. (Janné, 2021; Sezer et al., 2021).

5.1.3 Space constraints, material build-up, and time–space conflicts

Space limitations and changing conditions on site strongly amplify all other difficulties. Limited space reduces the capacity of the site to accommodate deviations and results in compromises such as temporary storage in inappropriate locations. Material accumulation was identified as a recurrent problem: Importation of more materials than can be consumed over a short period transforms the site into a warehouse and increases the extent of double handling, risks of damage and conflicts between trades. This confirms the importance of planning space requirements, of establishing zones for storage, and of minimizing conflicts between time and space requirements as major components of on-site logistics performance for urban construction projects.

This observation is consistent with the literature describing site layout planning and storage zoning as core elements of on-site logistics, particularly in dense urban projects where limited space increases the risk of congestion and repeated handling (Janné, 2021; Andersson & Nilsson, 2018; Forsemalm, 2023). Prior research also links delivery patterns and clustering to time–space conflicts on site, showing how variability in arrivals can overload access points and unloading capacity and thereby amplify storage and congestion problems (Sezer et al., 2021; Janné, 2021).

Major results of recent interviews confirm the mechanism for material accumulation and congestion. Projects generally fail to convert requirements for materials into requirements for volumes of transportation, and experience unexpected "volume shocks" with arrival of large quantities of materials even though requirements for materials were substantially lower. However, experience with more stringent conditions for space requirements resulted in earlier planning and greater discipline of coordination, and ultimately in improved capacity for planning and for anticipating requirements for materials and volumes of transportation. This provides further confirmation for the general conclusion that constraints can stimulate improved behaviour for planning, and that perceived flexibility may encourage the use of ad hoc methods that eventually produce losses of efficiency.

Finally, it can be confirmed that on-site logistics cannot be completely separated from activities of the upstream supply system. Materials generally are consumed in small batches, whereas supplies generally are delivered in large batches. This results in a mismatch of rates of consumption and delivery, and contributes to occurrences of shortages or excessive quantities with consequent requirements for additional storage on site. In general, the results confirm that many problems encountered at the site reflect in part difficulties with integration and coordination of activities of planning and delivery within the upstream supply system.

5.1.4 Cultural resistance and incentives that reinforce current practice

Another major challenge reported in multiple interviews was resistance to change and low levels of digital maturity. Respondents described continued reliance on such traditional methods as whiteboards and telephone communication, and resistance to basic digital tools. This underlines the importance of a well-functioning digital infrastructure for successful implementation of AI. Inadequate use of tools for planning digital delivery resulted in an unreliable basis for more advanced applications.

This aligns with research emphasizing that fragmented information flows and low digital maturity reduce the reliability of shared planning information, which in turn limits the effectiveness of digital coordination systems in construction logistics (Bosch-Sijtsema & Sundquist, 2022; Fredriksson, 2024). The results also reflect the literature's view that implementation barriers are often shaped by organizational ownership and governance: when responsibilities are dispersed and routines are not standardized, adoption tends to depend on individual motivation rather than institutionalized processes (Haglund, 2024; Janné & Rudberg, 2022).

Investments in data collection and implementation of well-structured procedures provided potential benefits for following projects. However, incentives for fast delivery, cost control, and short-term performance were prioritised instead. This confirms the view that barriers to implementation reflect not only technological limitations, but also important organizational and incentive constraints like those mentioned in the literature on requirements for ownership, maturity and quality of management of digital implementation.

5.1.5 Summary of RQ1

The most frequent on-site logistics problems identified in this study were reactive planning and late involvement of logistics functions, fragmented information flows among multiple actors and time-space conflicts arising from variability in delivery times and accumulation of materials. These difficulties were increased by cultural resistance to incentive structures that impeded development of standardized methods for consistent application of digital technologies. Overall, the results confirm that most on-site logistics problems reflect underlying systemic conditions of organization, coordination and information control, and are not primarily attributable to technical limitations.

5.2 AI to support on-site logistics processes

The discussion will explore where AI can realistically contribute to improving on-site logistics and under what conditions an implementation is feasible.

5.2.1 AI as decision-support

The findings from the interviews suggest that AI is primarily viewed as a tool to support decision-making rather than as a replacement for human expertise. While respondents generally had a positive attitude towards AI and its future potential, they consistently emphasized that professional judgement, contextual understanding and practical experience are still required for logistics planning and coordination. These findings are aligned with existing literature which describes construction projects as highly dynamic and uncertain environments, where decision-making often depends on changing site conditions, incomplete information and coordination between multiple stakeholders (Fredriksson, 2024; Janné, 2021).

A repeating theme in both the interviews and the literature is that decisions related to logistics are rarely fully standardized. Site layouts, delivery priorities, lifting operations and storage allocation change continuously during project execution which makes it difficult to rely only on automated systems. Although AI can process large amounts of data and identify patterns more efficiently than humans can, the interviewees emphasized that the outputs still require interpretation and validation by experienced professionals. This supports the argument presented by Abioye et al. (2021) and Elmousalami et al. (2025), who describe the "black box" problem of AI systems, where users may struggle to understand and trust how recommendations are generated. This lack of transparency can reduce trust in AI-generated decisions. However, the development of transparent and explainable AI systems are likely to eliminate that hurdle in the future.

The interviews further suggest that skepticism towards fully autonomous systems is not only technological but also cultural. The construction industry is strongly characterized by practical experience, informal communication, and reactive problem-solving. Multiple respondents described how companies continue to rely on traditional methods and established work routines, even in situations where digital tools are available. This resistance to change appears to be particularly important in logistics planning, where many decisions are still coordinated through phone calls, spreadsheets, or manual planning boards.

A reason for this resistance could be the lack of knowledge about certain tools or AI systems and their capabilities. An increased demonstration of benefits that new technologies bring to the daily work could help to decrease the resistance among many practitioners. However, these benefits should focus particularly on the person themselves by making their daily work easier, more streamlined and effective. If those benefits turn out to be sustainable and work across many projects, the adoption of new technologies and especially AI systems will be moving forward more quickly.

At the same time, AI can still create substantial value when used as a collaborative planning tool. It can support logistics professionals by generating alternative layouts, identifying scheduling conflicts, forecasting congestion risks, or structuring fragmented project information. This interpretation corresponds with the literature, where AI is pictured as support for repeated decisions under uncertainty instead of autonomous control of construction processes. In this context, AI contributes by improving situational awareness and increasing the speed and quality of planning decisions while leaving final responsibility to human actors.

However, the extent to which AI can support decision-making likely depends on project characteristics and organizational maturity. Large urban projects with high logistical complexity, multiple subcontractors, and limited space may benefit more from AI-assisted planning because the number of interdependencies and constraints exceeds what individuals can efficiently manage manually. Smaller projects with simpler logistics structures may experience fewer benefits because planning complexity is lower and informal coordination remains manageable. Similarly, organizations with higher levels of BIM integration and structured digital workflows are likely better positioned to utilize AI effectively than firms relying primarily on manual processes and fragmented information flows.

5.2.2 AI support for planning and optimization processes

One of the areas where AI could have strong potential is construction site layout planning and space utilization. Both the interviews and the literature emphasize that urban construction projects are characterized by limited space, continuously changing site conditions, and strong competition for temporary storage areas, unloading zones, and access routes. These constraints create recurring coordination problems and frequently lead to congestion, double handling of materials, and inefficient workflows (Janné, 2021; Forsemalm, 2023).

Interviewees highlighted that site layouts are often planned too late and adjusted reactively during production instead of proactively during early project stages. In this context, AI-based optimization systems could assist by quickly generating and comparing multiple layout alternatives that minimize transport distances, reduce congestion, or improve resource utilization. Literature also demonstrates that optimization approaches such as Ant Colony Optimization (ACO) can reduce handling costs and improve safety performance by identifying more efficient arrangements of temporary facilities (Ning et al., 2011). Interviewees similarly described AI as particularly useful for generating "first draft" layout solutions or alternative planning scenarios that could support decision-making during early project phases.

However, the interviews also revealed important limitations. Several respondents emphasized that optimized layouts are only as reliable as the data and assumptions used as inputs. In practice, detailed production sequencing information is often incomplete or continuously changing which makes fully optimized planning difficult. This observation supports the argument made by Gehring et al. (2025), who identify lack of reliable data and high model complexity as major barriers for AI-based logistics optimization systems.

Another important process identified in both the interviews and literature is crane and lifting coordination. Interviewees described crane planning as a highly complex coordination task because lifting operations depend on ever changing site conditions, delivery schedules, storage locations, and production priorities. These characteristics make crane coordination particularly suitable for AI-supported optimization. Literature supports this interpretation. Azami et al. (2022) demonstrate how AI frameworks can use artificial neural networks and heuristic search methods to optimize crane configurations by evaluating safety requirements, costs, and operational constraints at the same time. Reinforcement learning approaches described by Elmousalami et al. (2025) also show potential for adapting resource allocation decisions based on changing project conditions.

When it comes to transport coordination and delivery planning, respondents described problems related to clustered deliveries, delayed arrivals, unsuitable vehicles, and insufficient communication between suppliers, drivers, and site personnel. These findings correspond closely with the literature review, which identifies delivery peaks, congestion, and poor coordination as central causes of logistics inefficiencies in urban construction projects (Sezer et al., 2021; Janné, 2021). The findings suggest that transport coordination is particularly suitable for AI-supported decision-making because it involves large volumes of repetitive and data-intensive processes. Delivery bookings, unloading schedules, gate access coordination, and routing decisions generate significant amounts of operational data that can potentially be analyzed to identify patterns, predict congestion risks, and optimize scheduling. AI systems therefore appear capable of supporting logistics planners by improving the predictability and coordination of material flows.

However, the findings also demonstrate that successful implementation not only depends on technology but also depends on organizational conditions. AI-based delivery coordination requires standardized booking procedures, reliable real-time data, and collaboration between contractors, suppliers, and logistics coordinators. Several interviewees noted that current practices remain fragmented and reactive, with insufficient communication between stakeholders. Under such conditions, AI systems may struggle because the information which is required for reliable predictions and optimization is inconsistent or incomplete.

5.2.3 Data quality and organizational maturity as the limiting factor

Although the interviews identified several promising applications for AI in construction logistics, the findings also suggest that the main barriers to implementation are organizational instead of technological. Across nearly all interviews, respondents emphasized fragmented information flows, insufficient planning routines, inconsistent data quality, and resistance to change as the primary challenges limiting both logistics performance and AI adoption. These findings strongly align with the literature, which repeatedly identifies low digital maturity, disconnected software systems, and lack of structured project data as major obstacles for AI implementation in construction (Bosch-Sijtsema & Sundquist, 2022; Elmousalami et al., 2025; Fredriksson, 2024).

Logistics-related information is often distributed across multiple actors, including contractors, subcontractors, suppliers, and consultants, who all use different systems and routines. As a result, critical information regarding deliveries, storage allocation, scheduling, or material status is often incomplete or delayed. Several respondents described situations where site personnel missed even basic information about upcoming deliveries or material requirements which forced workers to spend additional time collecting and verifying information manually. This fragmentation creates a significant challenge for AI-supported systems because they depend heavily on reliable and structured data inputs. While AI can process and analyze information efficiently, it cannot compensate for missing, inaccurate, or inconsistent data. This creates a paradox within construction logistics: the industry seeks AI to improve coordination and planning but the existing workflows and data structures are often insufficient to support reliable AI-generated outputs.

Another important barrier identified in both the interviews and literature is cultural resistance within the construction industry. Several respondents emphasized that companies often continue to use established practices even when more efficient digital alternatives are available. This resistance appears not only due to skepticism towards

AI itself but also because of broader organizational traditions within construction. This resistance may also stem from the constant tendency to practice reactive planning which produces time pressure and therefore older and trusted methods are preferred since the outcome and effectiveness of those methods are familiar. It appears that a key change needs to be made in the way of thinking about planning ahead of time. Investing more time at the beginning of a project can provide greater clarity throughout and reduce time pressure during execution. This would also pave the way for the implementation of new technologies and improved data collection methods, which would enable better construction logistics over time.

Cybersecurity and intellectual property protection were also highlighted as growing concerns, particularly when AI systems are integrated into professional platforms and cloud-based workflows. However, interviews have shown that companies are well aware of these concerns and treat them as very important. Therefore, this will not pose as a significant obstacle to the implementation of AI-assisted systems in the logistics sector.

5.2.4 Summary of RQ2

This study shows that AI has significant potential to support multiple processes within on-site construction logistics, particularly in areas characterized by high coordination complexity, repetitive decision-making, and dynamic project conditions. The findings from both the interviews and literature review indicate that AI can support construction site layout planning, crane location optimization, transport coordination, space utilization, scheduling, and logistics-related information management.

Within construction site layout and space utilization, AI can support planners by generating and evaluating alternative layout configurations under changing project constraints. Optimization-based systems can improve the allocation of storage areas, unloading zones, and temporary facilities while reducing congestion, unnecessary handling, and safety risks. Similarly, AI-supported crane optimization and lifting coordination can improve resource utilization and reduce bottlenecks by analyzing operational constraints and sequencing dependencies more efficiently than traditional manual planning approaches. AI systems can support forecasting of delivery conflicts, improve scheduling reliability, reduce congestion, and enhance coordination between suppliers, contractors, and site personnel.

However, the findings suggest that the future success of AI in on-site construction logistics depends less on the development of new optimization algorithms and more on improving organizational readiness, data quality, and stakeholder collaboration. AI implementation therefore cannot be viewed purely as a technological issue but must instead be understood as part of a broader digital and organizational transformation within the construction industry where major barriers include fragmented workflows, inconsistent data quality, limited digital maturity, and cultural resistance toward new technologies.

6 Conclusion

The overall aim of this thesis is to investigate how AI can be applied to improve on-site construction logistics, with a particular focus on decision-making, planning efficiency, and resource coordination. The results were obtained through a qualitative study methodology in cooperation with Bygglogistik and included a review of the literature and interviews with professionals responsible for logistics planning, coordination, control and project implementation. The results confirm that on-site logistics represent a critical but often neglected component of construction production, especially for projects in densely built urban areas where limited space, complex requirements for coordination of activities and frequent modifications of conditions produce substantial demands on daily operations.

The most common difficulties experienced by practitioners with respect to on-site logistics were inadequate early planning, poor integration of information, lack of space, delays in decision-making and resistance to changes in established modes of operation. Implementation of logistics activities was delayed until late stages of the project and was therefore handled primarily reactive instead of proactive. This resulted in problems of delays, congestion, double handling, difficulty locating materials, and inefficient utilization of shared resources such as areas for unloading, storage, operation of cranes, and use of hoists.

These problems reflected not only operational difficulties, but also fundamental patterns of organization including inadequate integration of logistics into early planning, poorly defined responsibilities and minimal use of formal methods of data representation.

Poor on-site logistics have major effects on project performance. Inefficient logistics result in increased costs, disruptions of schedules, reduced productivity, safety hazards, and unnecessary environmental impacts. Lack of coordination for incoming deliveries, inappropriate locations for stored materials, or failure to adapt site layouts to changing conditions leads to interference among several trades and activities. As a result, disturbances of logistics affect not only material flows, but also the overall stability and predictability of construction operations. Consequently, the results confirm the importance of treating on-site logistics as a strategic rather than only as a supportive activity.

The second objective of the study was to evaluate the potential for AI to support processes of on-site construction logistics including layout planning, optimization of crane locations, coordination of material deliveries, and utilization of space. Results confirm the strong potential for AI as a tool for support of decision making, especially for activities involving repetitive decisions, large volumes of information, and continuously changing conditions. However, the results also illustrate that AI should not be interpreted as a replacement for human knowledge, but as a tool to help raise productivity in the construction sector.

This complex and rapidly changing environment continues to require application of practical experience, attention to safety, and use of contextual judgment. Consequently, AI is of greatest value as a tool to improve quality of decisions, to provide alternative conditions of operation and to promote more proactive behavior by project personnel. Finally, successful application of AI to on-site construction logistics will depend on integration with existing methods of work and on increasing quality and quantity of data. The major conclusion is that technological limitations represent the least important barrier to the application of AI in construction. Success in application of AI will depend strongly on quality of data, degree of maturity for application of information technology, methods of organization for standardized procedures and willingness to provide conditions that allow effective implementation of technology-based methods of work.

Many construction logistics activities remain based on manual procedures, incomplete data, and experience-based control. In such circumstances, application of advanced AI optimization may result in unreliable or impractical solutions. Consequently, implementation of AI should be viewed as a progressive process of organizational development, not as a single technological intervention.

6.1 Practical recommendations and implementation

The implementation of AI for construction logistics should generally be incremental. Initial efforts are likely to be most successful when targeting routine administrative and coordination activities that provide clear operational benefits while requiring relatively limited disruption to existing ways of working. As digital integration increases, particularly through improved Building Information Modelling (BIM) integration, higher data quality and stronger organizational readiness, the potential for implementing more advanced AI-based decision support and optimization is expected to grow over time. This conclusion is supported by the empirical results, where interviewees repeatedly identified low-risk applications such as document generation, booking assistance, data structuring, and communication support as realistic starting points. Similar findings in prior research also suggest that digital implementation is most effective when organizations begin with limited pilot applications and progressively expand adoption as technological integration and data maturity develop.

6.1.1 Recommended implementation pathway

Based on the findings, a practical implementation pathway for AI in construction logistics can be described in four progressive stages.

- **Establish a digital baseline**

The initial effort focuses on strengthening the company's digital and organizational foundations. Consistent collection of structured data, standardized processes, and clear ownership of logistics information are prerequisites for any application of AI. Booking of deliveries must capture important information on vehicle types, requirements for unloading, responsible contacts, and destinations for delivery. In addition, the redundant manual data entry between procurement systems and logistics planning tools should be eliminated. This is backed up by the literature indicating that poor-quality and fragmented information formats represent major impediments to AI implementation (Abioye et al., 2021; Zhang et al., 2024).

- **Start with low-risk AI applications**

With a stable digital infrastructure in place, AI can first be applied to routine administrative work. Examples reported in the interviews included preparation of standard logistics documents, summarization of deviations, support for booking procedures, and organization of incoming information. These activities were generally considered labor-intensive but low risk, making them appropriate for pilot applications that provide immediate benefits while requiring minimal organizational change.

- **Expand to decision support and anomaly detection**

As data quality and user confidence increase, AI can support planning and coordination functions. Potential applications include identifying overloaded delivery schedules, missing deliveries, risks of congestion, and early indications of conflicts in space and time. Respondents characterized these functions as highly valuable because they enable practitioners to respond proactively rather than reactively.

- **Progress towards advanced optimization**

The final phase consists of more sophisticated applications such as optimization of layout configurations, crane positions, delivery schedules, and resource allocations. However, both the interviews and the literature indicate that these applications depend critically on detailed and reliable data for execution and planning. Optimization results are likely to be unreliable or impractical in the absence of accurate information regarding sequence requirements, equipment characteristics, and facility constraints. Consequently, the implementation of advanced AI applications should be considered a long-term objective rather than an immediate step in the adoption process.

6.1.2 Collaboration between construction and AI experts

Another important implication is the need for interdisciplinary collaboration. Several barriers to progress identified in both the interviews and the literature reflect gaps in understanding the limitations of AI capabilities and the requirements for preparing data and operations for AI applications. As noted by Abioye et al. (2021), expert knowledge is needed to work in collaboration with researchers and experienced AI professionals to integrate ideas and develop innovative solutions that address the needs of the construction industry. This is particularly important in construction logistics, where knowledge of sequencing constraints, safety requirements, and supplier interactions must be combined with expertise in data science, software engineering, and cybersecurity. Without such collaboration, AI applications may achieve high technical performance while remaining operationally irrelevant.

6.1.3 Data sharing and industry-wide learning

A major limitation is the limited sharing of high-quality historical data. Project teams generally do not systematically collect logistics data and often fail to share or reuse data across projects. Similar observations were made by Zhang et al. (2021), who stated that "because of the inability to share historical data, it is difficult to learn from experience with previous similar projects when initiating a new construction project." Consequently, greater availability of open-source data will be essential for achieving intelligent development within the construction industry and will require continued efforts from government and academic institutions.

This experience confirms that AI adoption should not be viewed solely as an internal company activity. While improved methods of data collection and standardization can support the progress of individual organizations, broader advancements will require common data standards and collaborative efforts among industry, academia, and government. In the context of Swedish construction practices, such initiatives would enhance the capacity for systematic learning across projects and help establish the "learning platforms" that are currently lacking.

6.1.4 Summary

The present study supports the view that implementation of AI in construction logistics should initially focus on simple, credible applications that improve routine coordination work and reduce administrative effort. More sophisticated tools for decision support and optimization will become increasingly feasible with higher levels of digital integration, adoption of BIM, and improved data quality. Successful implementation will require substantial efforts in internal organizational development as well as integration with other members of the construction industry. Finally, the results confirm that the greatest benefit of AI comes from enhancing information systems, work procedures, and decision-making processes that support effective on-site logistics, rather than from replacing human expertise.

6.2 Limitations and future research

This study is limited by its qualitative and case-based design. Results are based on interviews and the literature, rather than on evaluation of a specific AI tool or quantification of improvements in efficiency. Consequently, the results represent an exploratory effort to identify potential applications of AI, practical barriers to implementation and conditions for successful application, but not proof of measurable improvements in efficiency.

Future work should extend the present investigation by testing specific AI-based tools for logistics applications in actual construction projects. This should allow evaluation of the potential for reductions in waiting time, duplication of handling, conflicts in storage and deviations in delivery. In addition, the extent to which logistics data should be integrated among projects to support application of machine learning and continuous improvement should be evaluated. Finally, the methods for achieving appropriate levels of responsibility, trust and accountability for decisions involving AI-based tools should be examined.

Ultimately, AI offers substantial potential for improvement of on-site construction logistics, but only with realistic approaches to implementation. The greatest immediate benefits will result from improvements in management of information, reductions in administrative workload and increased capacity for proactive coordination. In the longer term, there will be greater potential for the application of advanced optimization methods, depending on the quality of the data, the precision of the process definitions and the degree to which digital capabilities have been developed. As a consequence, use of AI should be considered as part of a broader effort to achieve greater levels of organization, application of quantitative methods and capacity for proactive management of construction logistics.

7 Appendix

7.1 Interview guide

Background:

0. What is your role and how are you involved in on-site logistics?

Main questions:

1. **On-site logistics scope**
   a. When you say “on-site logistics” in your work, what activities does it include?
2. **Typical Problems/Challenges**
   a. Which are the typical problems you see associated with on-site logistics?
3. **Consequences**
   a. Why do you think these are the most important problems and what consequences do they lead to on-site?
4. **Root Causes**
   a. Why do you think these problems happen?
5. **Key decisions**
   a. Which decisions are most important for on-site logistics and why?
6. **Current way of working (data/tools)**
   a. How are these decisions currently made in practice and what information or tools do you rely on?
7. **Current AI Use**
   a. Do you use any kind of AI today in your daily work? If yes, how? If not, why not?
8. **AI Potential**
   a. Which of the problems you mentioned do you think AI could help improve, and how?
9. **Barriers to AI adoption**
   a. What do you see as the main challenges for using AI in on-site logistics?
10. **Risks**
    a. What risks do you see with AI use in on-site logistics?
11. **Practical first step**
    a. If you were to start using AI more in your company, what would be a realistic first use case/pilot and what would be needed for it to work?

Closing:

12. If you could change/improve one thing about your daily workflow or in on-site logistics in general, what would it be?

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