TALLINNA TEHNIKAÜLIKOOL

TÖÖOHUTUSE KULTUUR EESTI EHITUSPLATSIDEL

SAFETY CULTURE ON ESTONIAN CONSTRUCTION SITES

MAGISTRITÖÖ

Üliõpilane: Carina Bitšikov

Üliõpilaskood: 182380EAEI

Juhendaja: Emlyn David Qivitoq Witt

Tallinn 2023

Non-exclusive licence for reproduction and publication of a graduation thesis

I, **Carina Bitšikov**,

1. grant Tallinn University of Technology free licence (non-exclusive licence) for my thesis
Safety culture and safety climate on Estonian construction sites
supervised by **Emlyn David Qivitoq Witt**

1.1 to be reproduced for the purposes of preservation and electronic publication of the graduation thesis, incl. to be entered in the digital collection of the library of Tallinn University of Technology until expiry of the term of copyright;

1.2 to be published via the web of Tallinn University of Technology, incl. to be entered in the digital collection of the library of Tallinn University of Technology until expiry of the term of copyright.

2. I am aware that the author also retains the rights specified in clause 1 of the non-exclusive licence.

3. I confirm that granting the non-exclusive licence does not infringe other persons' intellectual property rights, the rights arising from the Personal Data Protection Act or rights arising from other legislation.

15.11.2023

LÕPUTÖÖ ÜLESANNE

Üliõpilane: **CARINA BITŠIKOV**   Üliõpilaskood **182380**

Õppekava: **EAEI02 Ehitiste projekteerimine ja ehitusjuhtimine**
Peaeriala: Ehitusjuhtimine

Lõputöö teema:

TÖÖOHUTUSE KULUTUUR EESTI EHITUSPLATSIDEL

SAFETY CULTURE ON ESTONIAN CONSTRUCTION SITES

Juhendaja: **Emlyn David Qivitoq Witt**   emlyn.witt@taltech.ee

Lõputöö konsultandid:

Tiitel või ametikoht, Ees- ja Perekonnanimi	Kontakt (e-post või telefon)	Allkiri ja kuupäev
		_____
		_____
		_____

Lõputöö põhieesmärgid:

1. To understand the main types and causes of accidents on construction sites
2. To observe the behaviours of workers and establish what is the current safety culture on construction sites
3. To determine what influences the safety culture on construction sites
4. To understand how managers assess the risks of potentially dangerous situations
5. To understand how managers shape the safety culture on construction sites
6. To identify management actions that improve safety culture
7. To recommend how to shape safety culture on construction sites

Töö keel: inglise keel

Lõputöö etapid ja ajakava:

	Ülesande kirjeldus	Tähtaeg
1.	Analyzing data from historical work accidents	15.02.2023
2.	Observing workers' behavior on construction sites and conducting worker interviews.	03.09.2023
3.	Analyzing the results of observations and interviews of workers to identify main problems regarding site safety culture on construction site	20.09.2023
4.	Reviewing relevant literature on safety on construction sites and cultures with respect to risk in the work place	15.10.2023
5.	Collecting data through a questionnaire and interviews of for construction site / safety managers	20.10.2023
6.	Analyzing data from observations, interviews and questionnaires.	29.10.2023
7.	Interpreting the analysis results and formulating conclusions and recommendations	08.05.2023
8.	Completing the thesis write-up	

Lõputööde ülevaatus, mille läbimine on kaitsmise eelduseks	24.11.2023

Peale ülevaatust saab teha väiksemaid korrektuure ja üles laadida töö Moodle keskkonda plagiaadikontrolliks ÜHE pdf failina.

Esitlusmaterjalid kaitsmisel: Powerpoint esitlus ja jaotusmaterjalid

	Kirjeldus	Tähtaeg
1	Preparing a presentation	10.12.2023

Lõputöö esitamise tähtaeg: 4. detsember 2023

Plagiaadikontrolli läbinud lõputöö digiallkirjastatakse autori, juhendaja(te), konsultandi(tide) ja kaitsmiskomisjoni esimehe poolt. Paberil pole vaja allkirju koguda.

Lõputöö ülesanne välja antud: 09.10.2023

Juhendaja: **Emlyn David Qivitoq Witt** _____

Ülesande vastu võtnud: **Carina Bitšikov** _____

Avalikustamise piirangu tingimused: puuduvad

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

1.1 Importance of safety on construction sites

The construction industry is an accident-prone environment if not managed properly and safely. While the amount of accidents at construction sites in Estonia has decreased over the years, there still continues to be many. (Tööinspektsioon, 2022) From Figure 1.1 it can be seen that Estonia has a high incidence rate of fatal accidents at work compared to nearby countries. The data includes agriculture, industry and construction, and the services of business economy. The incidence rate is the ratio between the number of accidents per 100,000 population. (EUROSTAT, 2023)
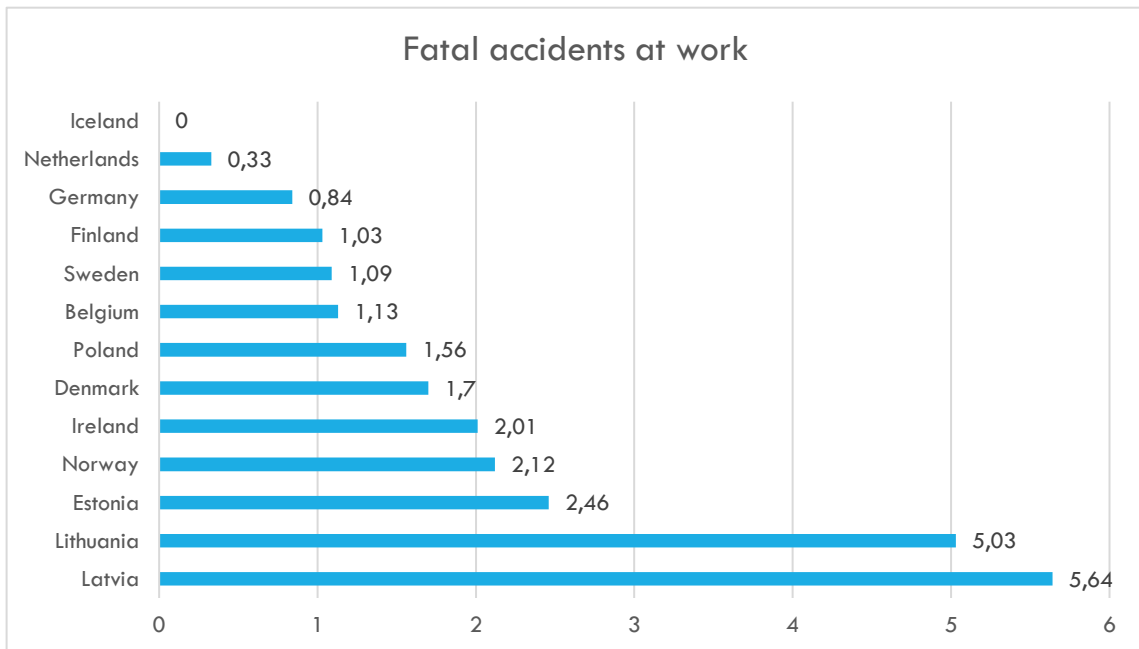
Figure 1.1 Fatal accidents at work per 100.000 population

In order to make construction sites safer and reduce the number of accidents at work, it is important to understand the current state of Estonian construction sites. To do this, the attitudes and behaviour of workers and managers with regard to safety in the workplace must be examined. Numerous factors influence the assurance of occupational safety, and a comprehensive assessment of these factors provides the opportunity to determine the next development steps after assessing the situation. (Al-Bayati A. , 2022)

1.2 Safety culture

The terms "safety culture" and "safety climate" have emerged as important concepts for understanding and promoting a safe working environment in construction projects (Al-Bayati A. , 2022).

Safety culture encompasses the shared values, beliefs and attitudes towards safety within an organisation. It represents the collective commitment to prioritise safety and influences behaviour, decision-making and the overall approach to risk management. (Zohar, 2010) In the construction industry, a solid safety culture is fundamental to preventing accidents, injuries and fatalities that can result from the inherently dangerous nature of construction work. (Al-Bayati A. , 2022)

Safety climate, on the other hand, typically carries a narrower meaning and focuses on the immediate perceptions and attitudes towards safety in a specific working environment. (Han, Son, & Kim, 2021) In this thesis, the term "safety culture" is preferred and used as the general term as it has a wider, organisational scope which, for the purpose of this research, is considered to encompass the safety climate(s) of the specific working environment(s) that construction workers and managers encounter. The term "safety climate" is used only when referring to specific working environments, and in relation to literature which specifies this term.

1.3 Thesis objectives and structure

The thesis examines the concepts of safety culture and safety climate in the construction industry and introduces assessment methods to evaluate their presence and impact. The study addresses the dimensions of safety culture, dissects its key elements and explains its crucial role in shaping behaviour and risk management. The study uses a mix of quantitative and qualitative approaches and relies on the OSHA database, on-site observations and interviews with managers to collect data. This methodology enables a comprehensive understanding of the safety culture on Estonian construction sites.

The main objectives of this work are to investigate accident types and causes on construction sites, observe workers' behaviour to assess safety culture, analyse factors influencing safety culture, evaluate managers' risk assessment practises, investigate managers' influence on safety culture, identify effective management actions and recommend strategies to improve safety culture.

2 LITERATURE REVIEW

Safety culture and climate in organisations are components that have a significant impact on workplace safety, employee wellbeing and operational efficiency (Schein, 2004). This literature review looks at the concept of safety culture and examines various models and frameworks for analysing this culture, including Schein and Hudson's models of safety culture and tools such as Zohar's Safety Climate Scale and the Nordic Occupational Safety Climate Questionnaire for assessing safety climate.

Key elements of safety culture, such as leadership commitment, employee commitment, open communication, continuous learning, and accountability are analysed (Zohar, 2000). The importance of a safety culture is reflected in its contribution to accident prevention, legal compliance and economic impact. The factors that influence safety culture - the management of multilingual environments, the role of management behaviour and the influence of the human factor - are examined. By examining these facets, the importance of safety culture in organisations and its potential to improve workplace safety and overall organisational performance will be highlighted.

2.1 Models and Frameworks for Analysing Safety

Various methods and practises have been developed to create a culture of safety in the workplace. In the following chapter we will take a closer look at these. Safety culture and safety climate assessment models are essential in organisations as they provide structured methods for assessing and understanding the multi-layered nature of an organisation's safety practises, helping to review and improve them (Arzahan, Ismail, & Yasin, 2022) .

The culture and climate of occupational safety in the construction industry has been studied the most compared to other sectors. Han, Son and Kim (2021) conducted a study in which they examined the literature on workplace safety. 36% of the literature they reviewed was related to construction. (Han, Son, & Kim, 2021)

In the literature that deals with the topic of safety, terms such as safety culture and safety climate appear again and again. Some researchers use the terms simultaneously, but Arzahan, et al., (2022) and Yari, et al., (2019) have examined various research papers and summarised the meanings of the two terms. Safety culture is often defined as a collective system of beliefs, attitudes and behaviours within a larger organisation, group or even industry. Safety climate refers more to the individual perception of the working environment. Table 2.1 shows how safety culture and climate can be

differentiated in five aspects: definition, scope, characteristics, influence and focus. (Arzahan, Ismail, & Yasin, 2022) (Yari, Naseri, Akbari, Shahsavari, & Hesam, 2019)

Table 2.1 Safety culture vs safety climate (Arzahan, Ismail, & Yasin, 2022) (Yari, Naseri, Akbari, Shahsavari, & Hesam, 2019)

Aspect	Safety Culture	Safety Climate
Definition	Refers to the shared values, beliefs, attitudes, and behaviours related to safety within an organisation.	Focuses on the perceptions, attitudes, and behaviours of employees within a specific workplace or department.
Scope	Broader and deeper, focuses on an organisation's overall approach to safety.	Narrower in scope, focusing on the immediate safety perceptions, attitudes, and behaviours of employees within a particular group or location.
Characteristics	Fosters proactive safety behaviours, open communication about safety concerns, shared responsibility for safety, and continuous improvement.	Reflects how employees within a specific area or department perceive and act on safety issues, more immediate and localized.
Influence	Influences the overall approach to safety management, leadership, and decision-making throughout an organisation. Extends beyond individuals and spans the entire organisation.	Influences how employees approach safety in their daily tasks and interactions, affecting safety performance in a specific area or group.
Key Focus	Organisational values, deep-seated beliefs, and principles regarding safety.	Perceptions, attitudes, and behaviours of employees within a specific workplace or department.

2.2 Safety culture models

Various models have been created related to organisational culture. In this section two of the most widely used models are looked into.

Schein's model, also known as Schein's three levels of organisational culture, describes a model with three levels: Artefacts, espoused values and underlying assumptions. Artefacts are the first image of an organisation that emerges, it includes structures and processes that are put in place. Artefacts also include the dress, manners and working practises that can be seen. Artefacts are easy to recognise, but it is difficult to understand their meaning. Espoused values are the strategic goals of an organisation and the expected behaviours set by leaders and to be followed by others. The underlying assumptions are the norm in the organisation that everyone has agreed upon and are difficult to change. The model helps to identify, evaluate and change the culture of an organisation. By addressing the underlying assumptions that drive the organisation, it

is possible to change the organisational culture to promote a safe working environment and practise. (Schein, 2004)

Hudson's model or the Hudson Safety Culture Ladder (Hudson, 2007) has two more levels than Schein's model. The model has five different stages, each of which represents a different stage of safety culture in an organisation. The first stage is pathological, where there is a general belief that an unsafe environment is caused by and is the fault of the employees. The second stage is reactive, i.e. organisations begin to blame themselves and react when an injury or accident occurs. The third stage is calculative, where managers recognise the safety concerns but workers only act on instructions. The fourth stage is proactive, where workers are more likely to approach managers and are more willing to follow policies. The fifth and final stage is generative, where both managers and workers are involved in creating a safer work culture and safety is an integral part of the organisation. (Filho, Andrade, & Marinho, 2009)

Both models are used to assess safety culture, but each has a different approach. Hudson's safety model provides a visual representation of where an organisation is on the ladder and encourages an assessment of the current state of safety culture so that next steps can be taken to move from a pathological-reactive to a more proactive-generative culture. Schein's safety model helps to take a closer look at an organisation's values and underlying beliefs to identify the roots of behaviours. It can help identify patterns in an organisation that may need to be changed, but the model does not provide as specific a progression as Hudson's model.

2.2.1 Safety climate models / tools

As safety climate focuses on a more specific group, many tools have been developed that can be used to assess the safety climate in a work area. In this section, a well-known theoretical model and a safety climate assessment tool are analysed.

Zohar, a notable figure in the field of safety climate research, has developed a safety climate model that is used in a modified form to assess and improve safety in an organisation. The model recognises two primary levels, the individual and the organisational level. The organisational level consists of the organisation's policies, procedures and practises. The individual dimension is concerned with the perceptions and actions of workers in response to these established safety rules. The model recognises that the safety climate influences the safety-related behaviour of workers. A better safety climate encourages safe behaviour, while unsafe environments can lead to

riskier behaviour and are therefore more accident-prone. The individual and organisational level is usually measured through surveys, interviews and observations to determine the current safety climate of the organisation and the areas that need to be improved. (Zohar, 2010)

The Nordic occupational safety climate questionnaire (NOSACQ-50) is a tool that was designed for helping to identify the organisations safety climate to enhance safety. It is a free to use tool which helps to recognize perceptions of safety-related policies, procedures, practices, and perception of managers from a view of an employee. The reflection of employee's point of view over the set rules and regulations is important to prevent accidents. The questionnaire consists of 50 items that are grouped into seven safety climate dimensions. The dimensions cover management, empowerment, justice, employee commitment, communication, trust in co-workers, and a faith in a system. (NFA.dk, 2019)

However, it's important to recognize that in the dynamic context of construction companies, traditional survey-based models such as Zohar's model and NOSACQ-50 may encounter challenges. The concept of employing surveys as a means of data collection is conceptually sound and makes sense in theory, but it is often not applicable in construction companies and runs into practical issues. Larger construction sites experience a high turnover of workers, environment is constantly changing, work is fast paced and working conditions differ due to project complexity, weather and how the different work sections are managed (Jeelani & Gheisari, 2021). Due to the distinctive characteristics of construction sites, there is an ongoing search for a safety climate assessment tool that is well-suited and applicable to this specific environment.

2.2.2 Mixed model

When looking at a construction site safety assessment it becomes clear that just a culture or climate models and frameworks alone cannot fix the industry (Casey, Griffin, Harrison, & Neal, 2017). The dynamic nature of construction sites, marked by the presence of multiple subcontractors, a multicultural workforce, and high-risk work, underscores the critical need for robust coordination among all parties involved. Achieving higher levels of construction safety culture and climate is not only a fundamental requirement but also a shared responsibility that can have far-reaching implications for the well-being and safety of everyone on the construction site. (Al-Bayati A. , 2022)

Al-Bayati et al., (2018) proposed a mixed framework that could be used. The research looks the construction safety culture as a management level and the construction safety climate as the principles and policies on-site worker's level. With this categorisation the culture of site safety is a responsibility of upper management and of safety contractors. The climate of site safety is in the hands of frontline supervisors and workers involved.

Safety climate and culture are crucial factors in an organisation's control. Safety climate is influenced by collective perceptions and emphasizes practices, employee engagement, and decision-making participation. It fosters a sense of ownership and provides valuable insights to decision-makers. Safety culture, on the other hand, relies on shared assumptions about human behaviour and values proactive actions. These values are integrated into safety rules, offering flexibility for employees to adapt to specific circumstances. Together, these factors shape an organisation's approach to safety, fostering a proactive and engaged workforce (Casey, Griffin, Harrison, & Neal, 2017).

2.3 Safety culture concept and elements

A safety culture is the foundation of an organisation's commitment to safety, encompassing values, beliefs, and practices that influence the safety landscape. It is not just a set of rules, but also includes behaviour patterns, management styles, and shared values (Grissinger, 2014). This section looks into characteristics of safety culture - leadership commitment, employee commitment, open communication, continuous learning, and accountability. By understanding and actively fostering these components, organisations can create a safer, more resilient, and more productive work environment (Grissinger, 2014).

2.3.1 Leadership commitment

The management of the organisation will shape the work environment, which in turn shapes the culture of the organisation (Yukl, 1981). Example that leaders set in terms of safety has an impact on how employees view it (Neal & Griffin, 2006). When workers see that instructions and regulations also apply to managers who willingly comply with them and consider them essential, then workers also start paying more attention to safety requirements and are more likely to follow them. (Syed-Yahya, Idris, & Noblet, 2022)

Continuous safety improvement involves gathering and evaluating safety data, developing feedback systems, conducting root cause analyses, learning from mistakes, changing safety measures, and regularly assessing progress. Employees can provide valuable insights, and organisations should prioritize learning from mistakes and update safety policies. Regular tracking ensures desired results. (Kineber, Antwi-Afari, Elghaish, Zamil, & Alhusban, 2023)

Steinmann, Klug and Maier studied (2018) how leaders can enhance job safety attitudes. Research brought out that leaders can learn specific behaviours through training to foster a culture where safety is paramount. Training should cover vision communication, goal setting, guidance how leaders should adapt to different situations, and how leaders can support employees to overcome difficult situations. These skills should help to transfer necessary knowledge into daily work routines, improving safety practices. (Steinmann, Klug, & Maier, 2018)

Leadership commitment is crucial in creating a strong safety culture in a company. This commitment should come from top management to frontline supervisors. It is essential for leaders to prioritize safety and demonstrate their dedication to it.

2.3.2 Employee commitment

The overall contentment of employees with the safety culture within an organisation hinges greatly on the degree of commitment they exhibit. In particular, the commitment demonstrated by employees is intricately tied to the commitment levels of top management (Tappura, Jääskeläinen, & Pirhonen, 2022).

Studies have shown that accidents at work are mainly caused by ignorance or inadequate understanding of requirements (Tezel, Dobrucali, Demirkesen, Kiral, & Ates, 2021). To ensure that the occupational safety requirements are comprehensible to all, the Occupational Safety Inspectorate has issued materials based on which managers can build up a set of information to be passed on to employees (Tööinspektsioon, 2022).

A sense of safety in a team significantly influences construction workers' motivation, expectations, and perceptions of a safe or a risky behaviour. When workers feel that they are responsible for others safety as well then, they are more inclined to follow the rules, therefore a notable reduction in accidents and injuries can be seen. (Zhang, Liu, & Chu, 2023)

Keeping up with safety regulations at construction sites and passing them on to workers will improve compliance with safety requirements at work. The more aware both managers and workers are, the more the risk of occupational accidents potentially can be reduced.

2.3.3 Open communication

The better the communication between employees and managers, the faster the chance to identify threats is. If workers are not afraid to talk about dangerous situations, solutions to problems can be found more quickly. Managers should be approachable enough for employees to address them with their concerns. (Neal & Griffin, 2006)

For employees to be able to contribute to making work environment safer it is necessary to provide specific tools that employees can use to report incidents. Providing proper tools improves employee's ability to spot hazards and encourages to work in accordance with occupational safety requirements. (Cooper & Phillips, 2004)

A study about on-site safety knowledge transfer (2019) brought out that on-site managers should talk about safety even when workers are not eager to listen at first. The more the topic is discussed the better the overall understanding of safety on-site. It is managers job to inform workers about accident prevention methods and to encourage workers to give feedback to find suitable solutions. (Huang & Yang, 2019)

Open communication is a crucial part of safety culture. It enables workers to be more eager to report about hazardous situations and accidents to managers without having to be afraid of the consequences but rather promoting a trusting and considerate environment.

2.3.4 Continuous learning

A study about evaluation of a programme made to reduce slips, trips and falls investigates the effectiveness of continuous education. The study focuses on healthcare, but many parallels can be drawn with construction industry. In addition to noticing hazards, continuously educating employees about hazards reduced the number of occupational accidents. Every workplace has its own most dangerous zones or work practices that need to be addressed constantly to remind about the hazards. (Bell, et al., 2009)

Site safety has been investigated a lot and therefore new tools are being introduced to the construction sites to increase the safety trainings effect. A study involving augmented reality investigated ways of passing on information. Visualization technology turned out to be the most preferred and most effective method when considering employees knowledge retention. (Shringi, Arashour, Golafshani, Dwyer, & Kalutara, 2023)

Continuous learning in the context of safety culture means conducting regular safety trainings and providing education on the topic to keep workers well informed about the safety regulations and best practices.

2.3.5 Accountability

Accountability in view of safety culture means setting clear behavioural expectations and consequences if expectations are not met. Safety culture means that workers do not only take their own well-being into account but also understand that their behaviour can also influence others (Boysen, 2013)

Probst and Estrada (2010) explored if accountability plays any role in occupational safety. Research brought out that accountability promotes moral obligation in workers to put safe working practices first in daily tasks. When workers know what is expected from them and what are the consequences when expectations are not met, they are more likely to recognise and address potential hazards beforehand. This potentially leads to a decrease in the number of accidents and injuries that occur. (Probst & Estrada, 2010)

The relationship between accountability and safety performance in daily tasks also comes up in Zohar (2000) study. It brings out that organisations with a strong culture of accountability tend to experience fewer accidents and injuries. Clearly defined expectations and consequences motivate employees to comply with occupational safety requirements. (Zohar, A Group-Level Model of Safety Climate: Testing the Effect of Group Climate on Microaccidents in Manufacturing Jobs, 2000)

2.4 Importance of safety culture

Accident prevention, legal compliance, and economic impact are crucial aspects of maintaining a strong safety culture in any industry (Al-Bayati A. , 2022). The interplay

between these factors shapes the safety landscape within workplaces and holds profound implications for the well-being of employees, the stability of businesses, and the broader societal context (Al-Bayati A. , 2022). A robust safety culture not only aims to prevent accidents but also ensures strict adherence to legal regulations, thus helping to alleviate the economic consequences. This section delves into these three critical dimensions of safety culture and their intricate relationships.

2.4.1 Accident prevention

Accidents occur in every industry and lead to injuries and unexpected damage (Tööinspektsioon, 2022). Therefore, is an accident prevention one aspect of a safety culture and the relationship between safety culture and accident reduction has been noticed (Mokarami, Alizadeh, & Pordanjani, 2019).

Job safety analysis or a job risk assessment is a crucial process that evaluates the safety and accuracy of an operation by deconstructing tasks, identifying potential hazards, and suggesting safe work practices. (Brauer, 2006) A risk assessment of the working environment is a document that employers must update if conditions, tools, data, accidents, or illnesses are identified, or if the level of risk has changed due to these factors (Tööinspektsioon, 2023). At the same time, there are also downsides to risk analysis, as the process assumes that employees can anticipate the future and foresee all dangerous situations. Employees do not know how to assess all risks. In addition, risk analyses are mostly carried out by managers, and the potential risks that are written down might not get discussed with the whole team. (Int J Environ Res Public Health, 2020)

Study by Christian et al. (2009) investigated workplace safety regarding persons role and situational factors. Research showed that fewer accidents and injuries happen, when workers are trained, motivated, and positively encouraged to work according to safe work environment (Christian, Bradley-Geist, Wallace, & Burke, 2009). The same connection was found in Neal and Griffins (2006) research where the accident rates at individual and on a group, level decreased when taught proper behaviour and safety culture (Neal & Griffin, 2006).

To reduce accidents on construction sites, it is important that errors and causes of errors are investigated and analysed. As accidents on construction sites are often of greater weight, it is necessary to keep up to date with what is happening in the occupational safety sector to avoid having to learn from organisations own grave errors (Jeschke,

2022). Osei-Asibey, et. Al., (2021) research brought out that conducting accident investigations that involve management team responsible for the site, workers and safety officers helped to prevent the recurrence of accidents (Osei-Asibey, Ayarkwa, Acheamong, Adinyra, & Amoah, 2021).

These findings highlight the role of safety culture in accident prevention. A positive safety culture not only enhances safety motivation and behaviour but also significantly reduces accidents at both individual and group levels, contributing to a safer and more secure workplace for all employees.

2.4.2 Legal compliance

The safety manager's responsibilities encompass various key tasks, including designing and executing a safety management program, coordinating regulatory inspections, conducting safety training, assessing safety initiatives, and taking corrective actions as needed, managing safety-related budgets, and overseeing workers' compensation claims, all while ensuring strict adherence to relevant safety laws and regulations. (Karakhan & Ahmed, 2023)

Laws are in place to define the requirements for occupational health and safety applicable to employees and employers. These laws outline the rights and obligations of both employers and employees in establishing and maintaining a safe work environment for health. They also govern the organisation of occupational health and safety on both enterprise and national levels and establish the consequences for violations of occupational health and safety requirements. (Riigikogu, 1999)

Larger contractors have established a strong occupational safety culture. To safeguard their existing safety culture and ensure it is upheld in the future, these contractors frequently incorporate safety requirement compliance clauses into contracts. (Valluru, 2022)

2.4.3 Economic Impact

The consequences of accidents at work can affect society, workers, and businesses. Employees may suffer financially in addition to the physical consequences of the accident. In the case of employers, accidents at work may lead to a reduction in the efficiency of work, which may lead to changes in the working schedule, which in turn entail additional costs. (Battaglia, Frey, & Passetti, 2014)

Construction sites often face significant economic losses due to accidents, including medical bills and workers' compensation claims. Construction companies are responsible for hospital bills, rehabilitation costs, and ongoing medical treatments. Workers' compensation claims may include lost wages during recovery or long-term disability benefits. These financial burdens can be substantial, especially when accidents result in severe injuries or fatalities. (Shin, Oh, & Yi, 2011)

A study by Al-Bayati (2021) investigated if a company size has a roll on the construction safety climate. The study found that a bigger sized firm meant a more defined safety culture when looking at managers point of view, but the trend did not carry over to on site workers. (Al-Bayati A. J., 2021) A study by (Rahman, et al., 2022) of boiler accidents showed that non-skilled workers are more likely to cause accidents. The study's findings emphasize the significance of proper training and the employment of skilled operators to enhance safety and reduce the risk of accidents. (Rahman, et al., 2022)

2.5 Factors influencing safety culture

This chapter examines three pivotal factors influencing safety culture within the construction industry: management priorities, multilingual environments, and the human factor. Effective leadership and the balance between profit and safety are central to construction management priorities (Zohar, 2010), (Clarke, 2006), (Wilpert & Itoigawa, 2001), while multilingual environments pose challenges related to language barriers and cultural sensitivity. (Abdallah, Shaawat, & Almohassen, 2023), (Cox & Cheyne, 2000), (Afzal & Shafiq, 2021). The human factor encompasses understanding risk-taking behaviours, confidence, and the influence of fatigue on safety practices. (Brauer, 2006) (Gu & Guo, 2022) Throughout this chapter the relationships between these factors and their impact on safety culture in construction is explained in more detail.

2.5.1 Multilingual environments

A study about miscommunications on construction sites found out that language barriers can pose a significant risk in a multicultural team. Effective communication is essential for project success, and language differences can lead to misunderstandings,

misinterpretations, and reduced collaboration which in turn can cause violations of safety. (Abdallah, Shaawat, & Almohassen, 2023)

Cox, et al., (2000) research found that in organisations with a diverse workforce where multiple languages are spoken, communication can be a significant challenge. Effective safety communication is essential to establish a strong safety culture. Factors related to multilingual environments include language barriers, when employees don't speak the same language miscommunications can happen, difficulties translating the training materials into multiple languages and cultural sensitivity aspect where different culture norms have to be respected. (Cox & Cheyne, 2000)

A study by Afzal, et al., (2021) evaluated the effectiveness of using 4-Dimensional Building Information Models and Virtual Reality in simulating job-site safety instructions for a multilingual construction crew in the United Arab Emirates. The study found that VR can significantly enhance safety communication and training in multilingual construction environments. The technology only helps to overcome language barriers and provides a more interactive and immersive way to educate and prepare the workforce for safety on the job site. (Afzal & Shafiq, 2021)

2.5.2 Management priorities

Effective leadership is crucial for fostering a strong safety culture. It involves setting a clear safety vision, leading by example, and providing necessary resources. Leaders should communicate this vision effectively, ensuring an injury-free workplace. By demonstrating safe behaviour and providing training, equipment, and support, leaders encourage employees to follow safety protocols and contribute to a safer work environment. (Zohar, Thirty years of safety climate research: Reflections and future directions, 2010) & (Clarke, 2006)

While profit is a vital financial driver, prioritizing it over safety can negatively impact the culture. This can lead to cost-cutting measures that compromise safety, such as reducing safety training or delaying maintenance. Employee perception can also be affected, as they may perceive safety as less valued. A short-term focus on profit can result in accidents and long-term financial losses. Legal and reputational risks can also arise from ignoring safety concerns due to profit priorities. Balancing profit and safety is crucial for fostering a healthy and effective safety culture. (Wilpert & Itoigawa, 2001)

A study by Wu, et al., (2018) investigated how project performance of workers is affected by job burnout and work-family conflicts. The research underscores that work-

family conflict and job burnout exert harmful effects on project performance within construction firms. These consequences manifest as decreased productivity, heightened rates of employee absenteeism, and the potential for project completion delays. The study reccomends to adopt a humanized management approach, to make employees feel supported and balanced which in turn leads to productivenes and engagement in workpalce. (Wu, Wu, Li, & Dan, 2018)

2.5.3 The human factor

Roger L. Brauer (2006) stated that unsafe acts caused by humans are a considerable factor of accidents, therefore understanding the human behaviour and what shapes it, is necessary. Brauer stated that person's behaviour is learned through education and training. Education requires effective communication about potential hazards, proper protocol, and safe behaviour. Feedback on results is crucial for learning and promoting correct conduct. Individuals and groups should receive feedback on their performance, with immediate feedback being considered the most effective. (Brauer, 2006)

Some individuals have a predisposition to take risks. These risk-taking behaviours can manifest in various ways in the workplace, such as ignoring safety protocols, taking shortcuts, or not using protective equipment. When risk-taking individuals engage in such behaviours, they are more likely to experience workplace accidents. These accidents can range from minor incidents to severe injuries, depending on the nature of the risks taken and the safety measures in place. (Brauer, 2006).

A study by Gu, et al., (2022) of how fatigue affects safety behaviour highlights that physical and psychological fatigue, as well as personal and social identity variables, have a direct impact on an individual's intention to engage in safe behaviour. These factors significantly influence an individual's decision to prioritize safety in their actions. (Gu & Guo, 2022) Managers in the construction industry must always consider human factors, even when facing tight schedules and quick construction paces (Ranasinghe, et al., 2023).

3 METHOD

The present study aimed to get an overview of safety culture on Estonian construction sites by getting an overview of problematic work procedures and frequent injuries, observing real-time safety culture and safety performance on construction sites and employing questionnaires. This approach was determined to be the most appropriate after conducting a literature review, as presented in Figure 3.1

Figure 3.1 Methodology used for thesis

3.1 Research objectives

The research objectives of this thesis investigate safety culture on Estonian construction sites aiming to get a better insight into construction workers' and managers' attitudes, risk perception and assessment. These objectives include:

1. Investigating the main types and causes of accidents: The first objective seeks to provide insight into the primary types and underlying causes of accidents that occur on construction sites, shedding light on the factors contributing to safety challenges.

2. Observing worker behaviours and current safety culture: Through direct observations of worker behaviours, this objective aims to assess the existing safety culture on construction sites, uncovering the current attitudes, practices, and adherence to safety protocols.

3. Analysing influences on safety culture: This objective explores the factors that influence safety culture within the construction industry, including leadership, communication, training, and external influences such as regulations and industry standards.

4. Assessing managerial risk Assessment: Understanding how managers evaluate potentially hazardous situations and assess risks is the focus of this objective, providing valuable insights into risk management practices on construction sites.

5. Investigating managerial impact on safety culture: This objective focuses on managers in shaping safety culture and examines their contributions to fostering a safer working environment for construction teams.

6. Identifying management actions for improvement: By identifying specific managerial actions that have a positive impact on safety culture, this objective aims to bring out effective strategies for enhancing safety practices and fostering a culture of safety.

7. Recommending strategies for safety culture enhancement: Drawing from the study's findings, the final objective is to formulate recommendations for improving safety culture on construction sites, offering actionable guidance to organisations and stakeholders.

3.2 Data collection

3.2.1 Occupational Safety and Health Administration database

To gain a deeper understanding of safety culture on Estonian construction sites firstly a through analysis of occupational accidents and incidents was conducted based on the Occupational Safety and Health Administration database (Tööinspektsioon, 2022) which contains data on completed occupational accident cases in the period 2014-2021. Completed in the sense that all investigations concerning the accident are concluded. The data is updated once a year. Main objective was to figure out which kind of accidents happen the most and what are the main causes of accidents. Since employees bear the responsibility to report all workplace accidents, but only are obligated to investigate the accident when the consequences of the accident involve temporary disability, severe bodily harm, or loss of life (Tööinspektsioon, 2022), therefore the analysis of the causes has been carried out for a narrowed number of accidents.

The data base was analysed using a program Microsoft Excel. To analyse the table, the information related to the construction sites was filtered out in the "*onnetuse_tegevusala*" (accident occupation) column by choosing numbers starting from 41000-43999. Such a choice was made to study all accidents that are classified either simply as an accident that happened on the construction site or accidents that have a more specific explanation added and describe a more precise section of the work, for example, accidents that happened during plastering, demolition, or roof work ect. Since the table holds a lot of information a Pivot Table was created and used to help to filter, summarise and categorize the information more clearly and comprehensibly. From there, the main types of injuries columns - "*vigastatud_kehaosa"* (injured bodypart) *and* "*vigastuse_liik"* (injurie type), activities column - "*kokkupuute_vigastuse-laadi_materiaalne_mojur"* (a material effector of the nature of contact injury) and "*kokkupuude_vigastuse_laad"* (exposure_injury_type) and reasons why accidents happen columns - "*pohjused_UKV"* (reasons) were mainly investigated.

3.2.2 Conducting construction site observations

Based on the information obtained from the table of the Occupational Safety and Health Administration a structured observation strategy was deployed, with particular emphasis directed toward those work sections or situations that showed a higher accident frequency based on the dataset. However, any other possibly problematic

situations that stood out were also noted for a more detailed overview. The purpose of the observations was to identify violations of occupational safety requirements and possible dangerous situations. Observations were written down in a note-taking service Google Keep, from there it was easy to export files into computer to be able to import them into Microsoft Excel for further analysis.

Whenever possible, an interview was also conducted with the violator to understand the reasons and decisions that led to the employee's violation. However, interviews were not always feasible due to some workers being deeply engaged in their tasks, making it impractical to interrupt them for an interview. In some cases, workers were at a considerable distance form the observation point making interviewing logistically challenging. Some interviews were not conducted because of a language barrier, making it difficult to communicate effectively during the discussions, and in some cases, workers were reluctant to engage in interviews. This could be because of workers fearing the consequences of what an interview could entail, see the interview as a stressful situation (Kostovicova & Knott, 2020), or can not spare a moment for an interview due to the fast pace of work on construction sites (Ranasinghe, et al., 2023).

The observation for the research were carried out on ten distinct construction sites – Table 3.1 below gives a detailed overview of the sites visited. This study used convenience sampling to select construction sites based on accessibility and availability, encompassing various stages of construction, to provide a comprehensive examination of safety culture in Estonian construction sites. It is noteworthy that three of the sites were visited twice and one of the sites was the author's worksite, because of that the contact with the construction site was greater, therefore a greater number of violations were discovered. Revisiting construction sites can be justified by an alteration in the work sections, accompanied by changes in the workforce itself. These revisits provided a chance to observe and interview new group of workers and also compare how the compliance with occupational safety requirements change depending on the construction stage of the site.

To assess how construction sites correlate with unsafe situations or regulatory violations, four category classifications was made. This classification primarily revolves around the specific construction stage each site is currently in. This approach enables a more structured and targeted analysis of the work activities and progress associated with each stage, making an evaluation more organized and comprehensible.

1. Site preparation stage – site clearance work, excavation, foundation works, utilities installation, initial safety preparations.

2. Structural construction stage – concrete pouring, wall construction, framing works,
3. Building completion stage – insulation, interior walls and partitions, roofing, plumbing and electrical, flooring.
4. Finishing and interior stage – painting and wall coverings, cleaning, furnishing, finishing details.

Table 3.1 Construction sites visited

Site nr	Project description	Stage of construction
Construction site 1.1	New housing community	2. Structural construction
Construction site 1.2		3. Building completion
Construction site 1.3		4. Finishing and interior
Construction site 2.1	New housing community	2. Structural construction
Construction site 2.2		4. Finishing and interior
Construction site 3.1	New housing community	2. Structural construction
Construction site 3.2		3. Building completion
Construction site 4	Renovation of a communal building	4. Finishing and interior
Construction site 5	Construction of a new communal building	1. Site preparation stage
Construction site 6	Construction of a new communal building	2. Structural construction
Construction site 7	Construction of a new communal building	1. Site preparation stage
Construction site 8	New housing community	2. Structural construction
Construction site 9	Renovation of a housing community	3. Building completion
Construction site 10	New private housing	4. Finishing and interior

The examination of the observation results was conducted to gain insights into the primary occurrences of violations of occupational safety requirements and the presence of hazardous situations on construction sites. Further investigation into the literature revealed that, in addition to observations and employee interviews, it was imperative to comprehend the perspectives and attitudes of managers.

3.2.3 Interviews with managers

The study used convenience sampling to select construction managers for interviews, ensuring they were actively involved in daily on-site interactions with workers. This method allowed for efficient access to firsthand insights into safety culture dynamics within construction sites. The overview of interviews is in Table 2.2.

For the managers to be able to speak freely, it was confirmed that their names and companies' names mentioned during the interview will stay confidential. The interviews were conducted in different ways. Some interviewees were met one-on-one, other interviewees preferred to have a phone conversation. In both cases in the beginning of the interview it was firstly announced that the conversation was being recorded and managers were assured that the recorded conversation will not be put up anywhere and will only be used for the purpose of this research.

A structured questionnaire was developed for interviewing managers, forming the foundation for the interviews. While the initial questions provided a framework, the interviews were designed to be flexible, allowing for the emergence of new and insightful points during the discussions. The conversation flowed naturally, ensuring a dynamic exchange of ideas. However, it was ensured that all the key topics of interest were covered with each respondent. To maintain consistency, all recorded data was transcribed and analysed using Microsoft Excel, enabling a comprehensive exploration of the collected insights.

Table 3.2 Interviews overview

Job title	Experience in the construction industry	The duration of the (recorded) interview
Site engineer 1	3 years	11:15
Site manager 1	15 years	14:35
Site manager 1	8 years	15:11
Site engineer 2	2 years	13:56
Site manager 1	11 years	18:42
Site manager 1	5 years	18:03
Site engineer 3	2 years	15:52
Site manager 1	7 years	14:54
Site manager 1	8 years	17:06
Concrete works manager	9 years	14:09

3.2.4 Risk assessment

In addition to the interviews, a risk assessment form for site managers was developed using observation data and information obtained from the Occupational Safety and Health Administration dataset. The risk assessment included different work practises and the form is presented in the Appendix 1. Initially, when experimenting with Google Forms, it was observed that the desired level of flexibility for constructing the survey was lacking. Consequently, a Microsoft Excel table was distributed to managers via email to collect their input.

To fill the form managers had to use a 1-5 scale to assess the risk of each issue. For everyone to have a common understanding a legend was provided:

1. Very Low Risk - Minimal likelihood of occurrence and negligible consequences.

2. Low Risk - Low likelihood of occurrence and relatively minor consequences.

3. Moderate Risk - Moderate likelihood of occurrence with noticeable consequences.

4. High Risk - High likelihood of occurrence and significant consequences.

5. Very High Risk - Extremely likely to occur with severe consequences.

The information gathered from the survey was later compared to the data from site observations and the Occupational Safety and Health Administration dataset to assess whether the managers' risk analysis has similarities to the data found.

3.3 Data analysis method

This research employed a mixed methods approach that contains quantitative and qualitive research methods visually presented in a Figure 3.2 to gain a more comprehensive understanding of the research objectives. The mixed method design allowed to explore various dimensions of site safety culture.
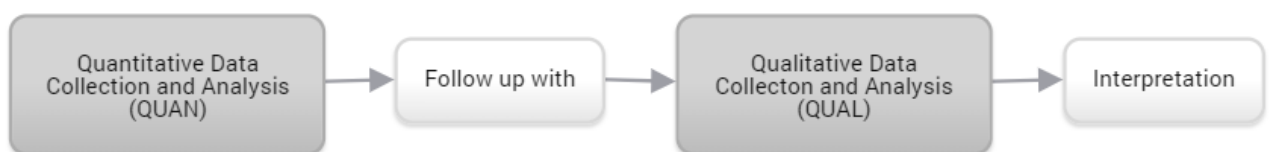
Figure 3.2 Explanatory sequential mixed method (Creswell, 2013)

Quantitative data research is a systematic approach to conducting research that primarily involves numerical data and statistical analysis. This methodology is widely used across various disciplines, including social sciences, natural sciences, business, and healthcare, to gather, analyse, and interpret data in a structured and objective manner. (Creswell, 2013) In this research quantitative data research method is used when analysing the OSHA database.

Qualitative research involves immersing researchers in the natural setting where participants experience the issue of study. Researchers directly interact with individuals, collecting data through methods like observing behaviour, interviews, and document examination, with themselves as the primary data-gathering instruments. Instead of relying on standardized questionnaires, qualitative researchers collect multiple forms of data, such as interviews, observations, and documents, and analyse it inductively, constructing themes and patterns that naturally emerge from the information. (Creswell, 2013), (Saldaña, 2013) Qualitative data research method in this research is used when analysing site observations and interviews with managers.

Coding in qualitative data analysis, is the process that involves categorizing and organizing data into themes and concepts. The concept of coding can be seen in the Figure 2.3. Coding allows to organize and to make sense of the data. Some categories may have subcategories within them. When major categories are compared and combined, research progresses beyond the raw data and moves toward developing a deeper understanding of themes, concepts, and potentially even theory. For protecting the confidentiality of individuals and companies during coding all the names mentioned are disassociated from the responses.
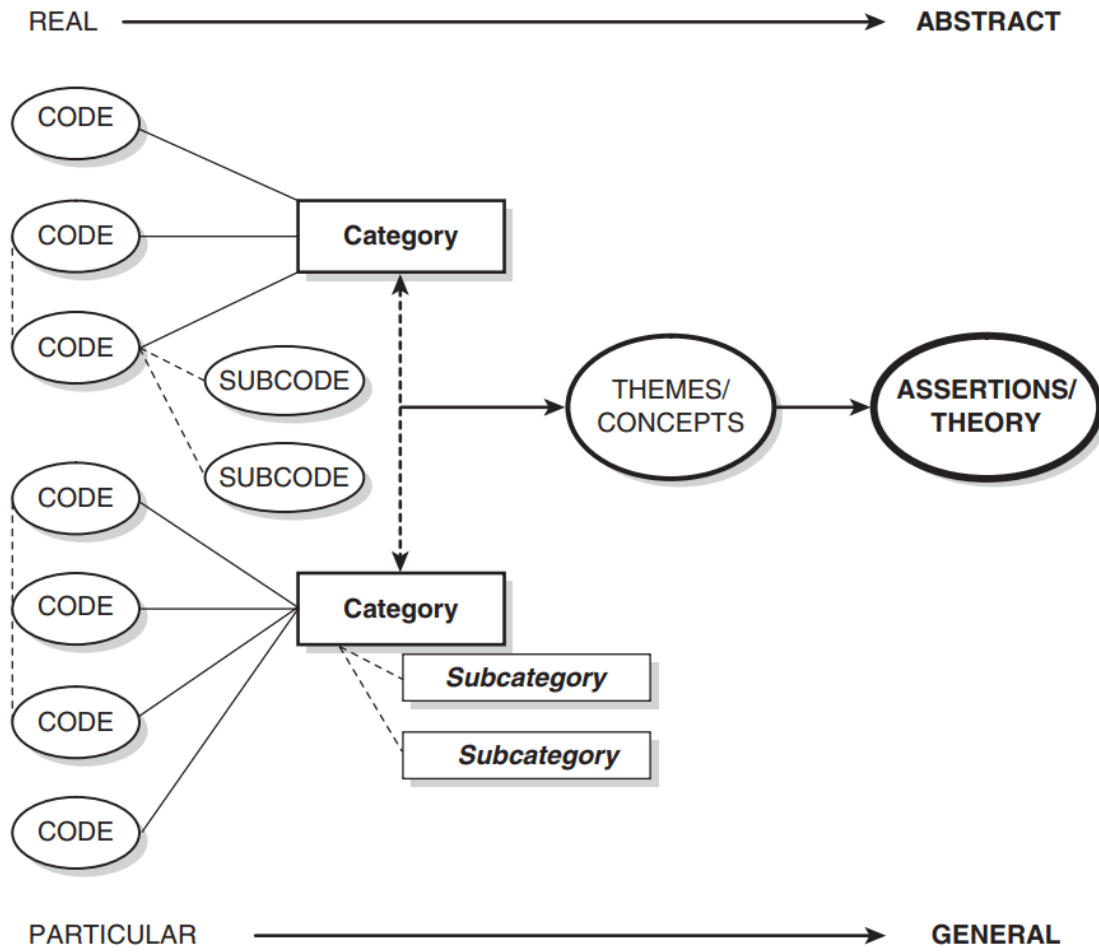
Figure 3.3 Codes to theory model (Saldaña, 2013)

4 RESEARCH FINDINGS

4.1 Occupational Safety and Health Administration database analysis

In this section, the Occupational Safety and Health Administration (OSHA) database will be analysed, with a primary focus on workplace injuries, the actions that lead to these injuries, and the underlying reasons behind these incidents.

4.1.1 Injuries

The research findings provide insights into the distribution of workplace injuries across different body parts and their severity levels. Two graphical representations have been utilized to present the data, allowing for a comprehensive understanding of the injury patterns.
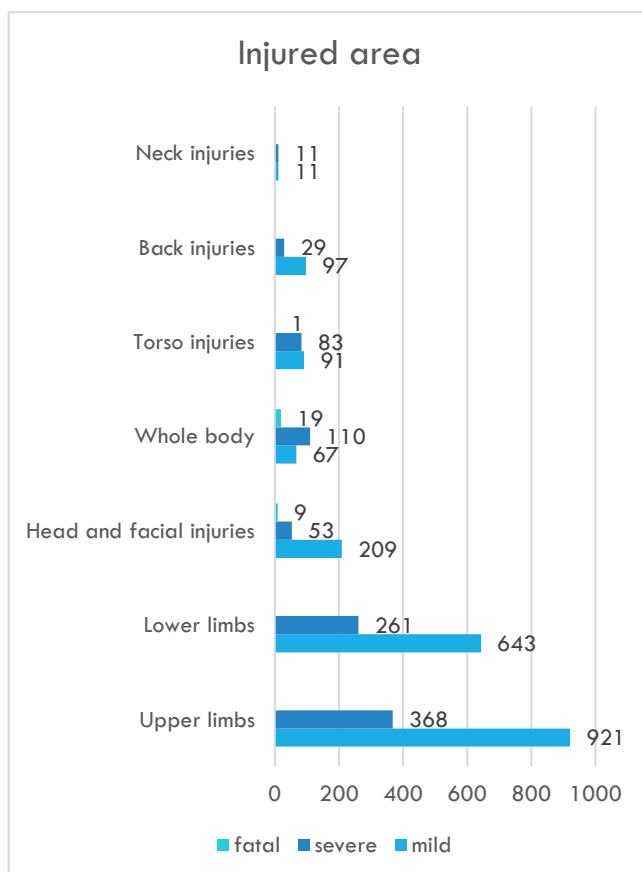
Figure 4.1 Injured area   Figure 4.2 Injured body part
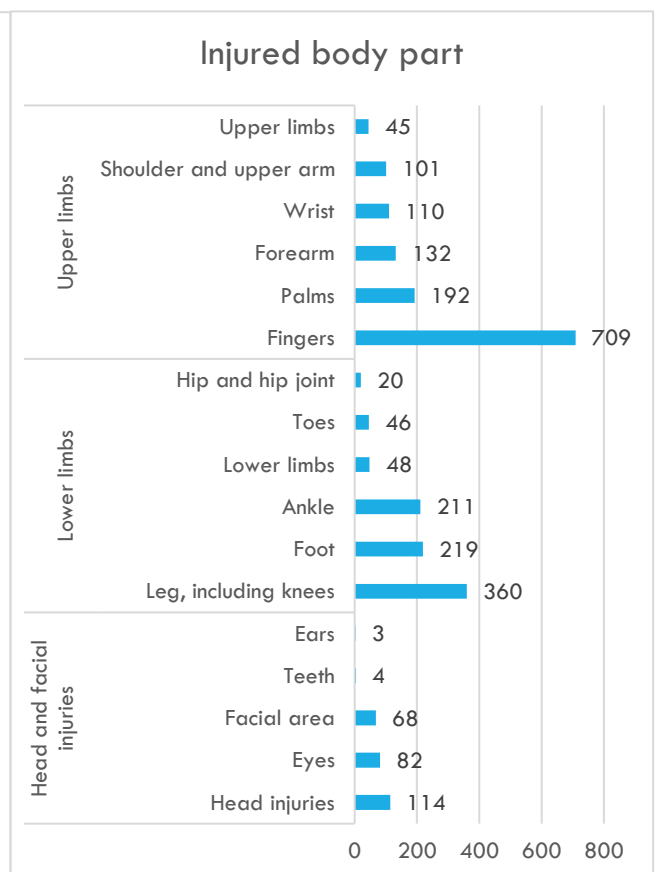
The Figure 4.1 represents categorized injuries based on their severity levels, distinguishing between "mild," "severe," and "fatal" injuries. The majority of reported

injuries fall into the category of "mild," with a total of 2039 cases. "Severe" injuries account for 915 cases, highlighting a significant number of serious incidents. While fatal injuries are relatively rare, they are still of great concern, with 29 reported cases. The total count of reported injuries across all severity levels amounts to 3198 cases. Injuries to the "upper limbs" are the most frequently reported, totaling 1289 cases, reflecting the need for focused attention on this body area. "Lower limbs" also account for a significant number of reported injuries, with 904 cases.

In the Figure 4.2 three categories with the most injuries are looked more deeply into. Fingers are the most frequently affected body parts, with 709 injuries. Legs and knees, foot, ankle report a notable number of injuries, with 360, 219 and 211 cases respectively. From head and facial injuries, the most common are head injuries with 114 cases and eye injuries with 82 cases.

4.1.2 Actions

The findings reveal a breakdown of reported workplace injuries by specific categories and factors. For the actions causing injuries the "kokkupuute_vigastuse laadi_materiaalne_mojur" (a material factor in the nature of the exposure injury) and "kokkupuude_vigastuse_laad" (exposure injury type) columns from the database were investigated.

The highest number of injuries, totaling 611, was associated with activities like walking, running, ascending, descending, and related actions. Working with manually operated hand tools accounted for 332 injuries, while climbing and ascending were responsible for 317 reported injuries. In addition, working with power hand tools contributed to 301 injuries. Manual activities involving grasping, holding, placing, etc., in a horizontal manner, resulted in 255 injuries. Vertical movements, including lifting, raising, or lowering items, were linked to 227 injuries. Lastly, on-site movements accounted for 130 reported injuries. The findings are shown in the Figure 4.3
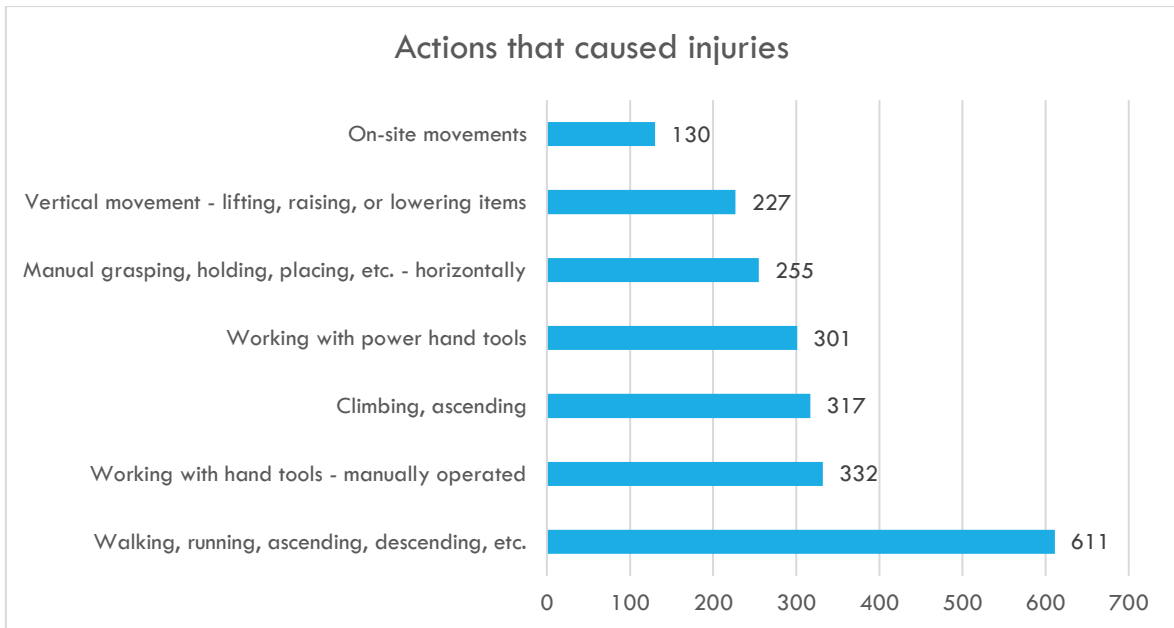
Figure 4.3 Actions that caused injuries

From each of the exposure injury types three main material factors were investigated. The most frequently reported factors include general surfaces 210 cases, mobile ladders and A-ladders 183 cases, hand tools like knives, axes, and cutters 139 cases, and staircases 75 cases. Additionally, power hand tools such as electric saws and thermal tools accounted for 62 cases. Flooring-related incidents resulted in 56 cases, while hand drills contributed to 40 cases. Other construction materials, including those not specified, were associated with 37 cases. Injuries involving hammers, mallets, and stone hammers constituted 36 cases. Mobile scaffolds, known as mobile scaffolding, contributed to 33 cases, and handling large construction materials resulted in 31 cases.

A bit less frequent factors were incidents with no specific material consequences accounted for 22 cases. Loads suspended from lifting equipment, such as cranes, were involved in 19 cases, while manually lifted loads contributed to 18 cases. Finished items, including doors, partitions, and windows, were associated with 18 cases. Wrenches led to 14 cases, non-mobile scaffolds resulted in 10 cases.

4.1.3 Causes of injuries

The analysis of the Occupational Safety and Health Administration (OSHA) database revealed various factors contributing to workplace injuries. For the causes of injuries the column "*pohjused_UKV*" (reasons) from the database was looked into. When filling out the report, it is possible to select several factors, so the number of times the factor

was mentioned was counted for the purpose of this research. The most frequently mentioned factor contributing to these injuries was "Violation of occupational safety requirements by an employee" with 1234 mentions, to which other clarifications were usually added.

The most frequently added clarifications included "Non-usage of personal protective equipment" mentioned 160 times. This suggests lapses in adhering to essential safety measures, putting workers at risk. The analysis also highlighted "Violation of occupational safety requirements by another employee," with 139 mentions, indicating the complexity of shared responsibilities in the workplace. "Non-compliance of buildings, workplaces, or pathways with safety requirements" was cited 124 times, underscoring the importance of maintaining safe physical environments to prevent accidents.

Issues related to safety management were evident, with "Insufficient internal workplace safety control" mentioned 115 times and "Insufficient training and guidance" reported 105 times. This implies the need for enhanced safety culture and management practices.

The results are also shown in the Figure 4.1.3, where less mentioned risk factors are also visible. "Violation of occupational safety requirements by an employee" factor was not included in the figure due to its high frequency of occurrence (1234 mentions), which overshadowed the comparatively lower frequency of the next factor (160 mentions). This exclusion was aimed to enhance the figure's readability and clarity.

Causes of injuries

Cause	Value
Violation of traffic laws by an employee	3
Intoxication (due to alcohol, narcotic, or psychotropic substance use)	3
Violation of requirements for the use of hazardous chemicals	5
Violation of traffic rules by an employee	13
Absence of personal protective equipment	19
Violation of traffic laws by another individual	33
Fatigue	36
Non-compliance of tools or equipment with safety requirements	94
Insufficient training and guidance	105
Insufficient internal workplace safety control	115
Non-compliance of buildings, workplaces, or pathways with safety requirements	124
Violation of occupational safety requirements by another employee	139
Non-usage of personal protective equipment	160

Figure 4.1.3 Causes of injuries

4.2 Construction site observations

This section highlights the key findings that emerged during observations conducted at construction sites. These findings have been categorized into four main categories. The first category focuses on the use of personal protective equipment, as the observations revealed several deficiencies in this aspect. The second category examines various work practices that may not be the most suitable and could potentially lead to accidents. In the third category, attention is directed towards the justifications provided by workers for their safety regulation violations. Lastly, the fourth category illustrates in which stages of construction there is the most significant lack of compliance with safety requirements.

The data from construction sites involves 52 observations, including both worker comments and direct observations. In 32 cases, only direct observations were recorded, as it was not feasible or reasonable to ask for worker comments. These observations capture information about safety practices and potential hazards at construction sites, enabling an assessment of the safety landscape even when verbal feedback was not feasible.

4.2.1 Hazardous work practices

In the Table 4.2.1 observations gathered in the construction sites about hazardous work practices are presented.

Table 4.1 Hazardous work practices

Hazardous work practice	Times reported	Hazardous work practice	Times reported
Hand and power tools	**21**	**Welding and cutting**	**5**
Lack of safety equipment	15	Lack of safety equipment	5
Lack of equipment safety	6	**Falling objects**	**5**
Working at heights	**17**	Lack of safety equipment	4
Risk of falling from heights	12	Lack of understanding language	1
Lack of safety equipment	4	**Ergonomic risks**	**3**
Lack of co-worker safety	1	Risk of tripping	2
Fall caused of slips, trips	**16**	Improper material handling	1
Risk of tripping	11	**Fire and explosion**	**2**
Risk of falling from heights	3	**Excavation and trenching**	**1**
Lack of safety equipment	2	**Electrical hazards**	**1**
Lifting and rigging	**8**	**Noise and vibration**	**1**
Improper material handling	2	**Respiratory hazards**	**1**
Lack of safety equipment	2	**Heavy machinery operations**	**1**
Lack of marking hazard area	2		
Risk of tripping	1		
Lack of co-worker safety	1		

The site observations revealed that hand and power tools were the most frequently cited hazardous work practices, with a total of 21 reported incidents. These incidents were often linked to a lack of adequate safety equipment and a deficiency in equipment safety protocols. Working at heights was the second most prevalent issue, with 17 incidents reported, primarily stemming from the risk of falling and a noticeable absence of the necessary safety gear. Slips and trips also featured prominently, with 16 reported incidents, underscoring the critical need to address floor hazards to minimize the risk of falls.

Among the medium common hazardous work practices, lifting and rigging practices were associated with 8 reported incidents. These incidents were frequently connected to improper material handling and a lack of essential safety equipment. Welding and cutting activities were involved in 5 incidents, primarily due to inadequate safety equipment. Falling objects, which present a potential danger on worksites, were

responsible for 5 incidents. Ergonomic risks were observed in 3 incidents, associated with tripping hazards and improper material handling.

Among the less frequent hazardous work practices, fire and explosion hazards were reported in 2 incidents. Excavation and trenching, electrical hazards, noise, vibration, and respiratory hazards each contributed to 1 incident.

4.2.2 Personal protective equipment

The data gathered from construction sites reveal the frequency of missing personal protective equipment (PPE) items. Gloves were the most frequently absent PPE, with 13 instances. Goggles and helmets were also frequently missing, with 10 and 8 occurrences, respectively. Harnesses and vests had 8 and 4 instances of non-compliance, respectively. Footwear was missing in 3 observations, while respirators, chinstraps, and earplugs were absent in 2, 1, and 1 case, respectively.

In the Figure 4.2.2 the most common excuses or justifications said when caught not wearing PPE are brought out. The excuses were split into five categories. "Disturbs work" relates to times when wearing PPE was uncomfortable or got in the way or work procedures. "Miscommunication" includes times when worker understood managers and given instructions differently. "N/a" category includes the cases where interviewing was not possible, or a worker did not want to give an explanation. "Quick action / forgot / no risk" includes all the justifications where the worker is focused only on work and has not considered the PPE necessary enough. "Was not given" includes justifications when a worker did not receive PPE from its manager prior to work.

The Figure 4.2.2 shows that the most common justification for not wearing PPE is "quick action / forgot / no risk" which was mentioned 21 times. Miscommunication happened 2 times and other given reasons were quite even with "disturbs work", "n/a", and "was not given" were said 9, 10, and 8 cases, respectively.
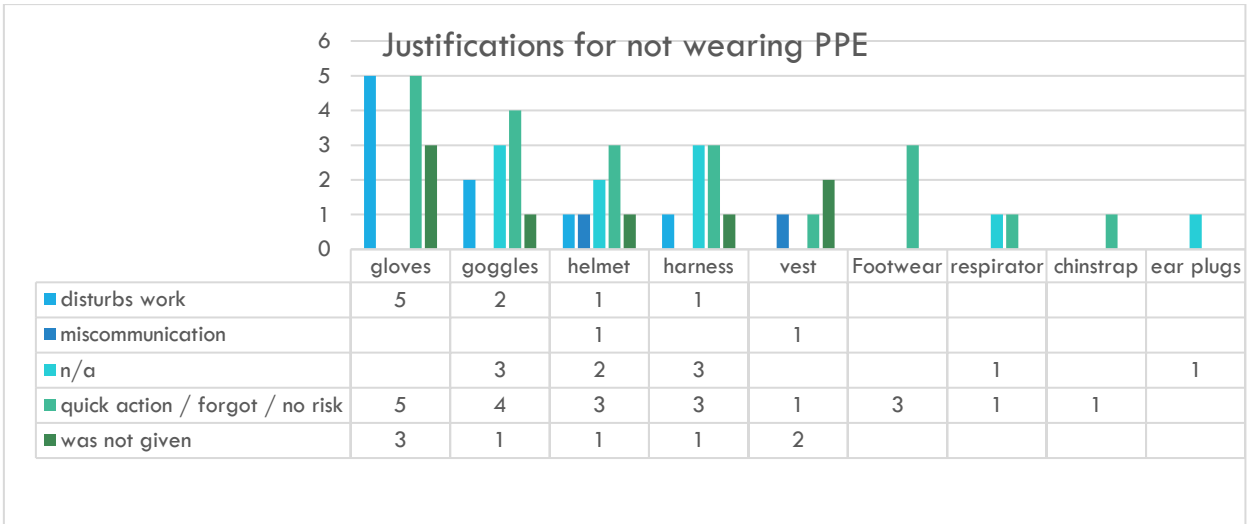
Figure 4.4 Justifications for not wearing PPE

	gloves	goggles	helmet	harness	vest	Footwear	respirator	chinstrap	ear plugs
disturbs work	5	2	1	1					
miscommunication			1		1				
n/a		3	2	3			1		1
quick action / forgot / no risk	5	4	3	3	1	3	1	1	
was not given	3	1	1	1	2				

4.2.3 Site construction stage

The Figure 4.2.3.1 provides insight into the construction phase with the highest percentage of shortcomings regarding occupational safety. The percentages were determined by considering the number of remarks on each site and comparing it to the number of sites falling within one of four categories – site preparation, structural construction, building completion and finishing and interior. It's important to note that certain construction sites in specific stages were visited more than others, therefore it was taken into account when finding the percentage.

Figure 4.5 Observations on different construction stages

4.3 Occupational safety risk matrix

The Table 4.3.1 summarizes the findings of risk assessments provided by 10 individuals, each evaluating various categories of potential risks within a construction environment. These categories encompass a wide range of hazards, from working at heights and falling objects to heavy machinery operations and excavation. The assessments considered two critical factors: the likelihood of each risk occurring and the severity of its potential impact. The risk level was calculated by combining these two factors, resulting in an overall risk score for each category. Notably, "Working at heights" received the highest risk score, indicating a significant level of concern, with "Falling objects" and "Heavy machinery operations" also ranking relatively high in terms of risk. These findings serve as a valuable reference for prioritizing safety measures and addressing potential hazards in the construction site. It is evident that certain categories demand heightened attention to ensure the well-being of workers and minimize on-site risks.
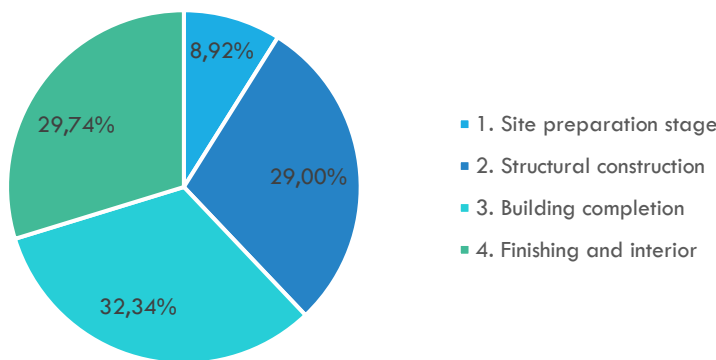
Table 4.2 Occupational safety risk matrix

Category	Likelihood of occurrence	Severity of impact	Risk level
Working at heights	3,4	4,6	15,6
Falling objects	3,3	3,9	12,9
Heavy machinery operations	2,6	4,7	12,2
Excavation and Trenching	2,5	4,5	11,3
Lifting and Rigging	2,6	4,2	10,9
Incoordination on site	3,4	2,8	9,5
Fall caused of slips, trips	4	2,3	9,2
Noise and vibration	2,9	2,6	7,5
Electrical hazards	1,8	3,8	6,8
Welding and cutting	3,6	1,9	6,8
Hand and power tools	3,4	2	6,8
Respiratory hazards	2,2	3	6,6
Fire and explosion	1,3	4,6	6,0
Ergonomic risks	2,6	2,1	5,5

4.4 Interviews with managers

The information was gathered from 10 managers. Firstly, the findings were coded and after coding were categorized into six key areas: communication and training, compliance and enforcement, external and environmental factors, management and

supervision, worker attitudes and behaviours, and workplace resources and conditions. These findings are presented in 6 tables in this paragraph.

Table 4.3 Communication and training findings

Communication and training	Different individuals	Times mentioned
Communication issues due to language barriers	5	6
Need of visually engaging safety briefings	5	5
Workers' knowledge of safety requirements relies on managers	5	5
Explanation of on-site hazards from various job perspectives	4	4
Restriction on loud music to ensure audible alarms	1	3
Lifting operation training is lacking	3	3
A need to enhance managers knowledge of safety	3	3
Making safety requirement information sheets available	3	3
Showing the importance of work tools and work clothes	2	2
Lack of sufficient knowledge about the hazards associated with materials used	1	1

Table 4.4 Compliance and enforcement findings

Compliance and enforcement	Different individuals	Times mentioned
Open communication is preferred by managers over fines	9	12
Fines are used as a punitive measure for non-compliance	9	11
Compliance with safety measures tends to be higher during the initial phases of a project	6	9
Safety equipment is accessible but frequently forgotten by workers	7	8
Safety equipment use is time consuming	6	7
Apparent compliance until managers leave	4	7
Safety is not a priority in smaller companies	5	6
Safety is not a priority in less qualified companies / for less qualified workers	3	5
Foreign workers tend to follow safety regulations less	4	5
The effectiveness of fines as a compliance method is debated	5	5
Sending a worker home if they do not comply with the safety requirements	3	3
Competent workers tend to follow safety regulations	2	2
Allowing safety violations even once can lead to ongoing non-compliance	1	1
Younger workers tend to adhere to safety requirements more effectively	1	1

Table 4.5 External and environmental factors findings

External and Environmental Factors	Different individuals	Times mentioned
Constant time pressure in construction	7	10
State-imposed safety requirements are considered stringent	7	8
Task-specific safety compliance	6	6
Foreign laborers bring diverse work cultures to construction sites	5	5
Clean construction sites lead to improved safety regulation compliance	5	5
Regulations should be more flexible	4	5
The market does not encourage attention to safety requirements	4	4
More tight schedules and lower budgets compared to neighbouring countries	2	3

Table 4.6 Management and supervision findings

Management and Supervision	Different individuals	Times mentioned
Repeated reminders are necessary to reinforce safety practices	8	12
Communicating with subcontractor managers to enhance safety practices	7	8
Three-level warning system	7	8
Clear safety directives from higher-level managers result in improved compliance at construction sites	5	7
The expense of standard safety equipment is a concern	7	7
Managers set the example	5	7
Upper management visits on site encourage site cleanliness	4	5
Often seen safety inspector impacts safety compliance	5	5
Safety compliance reflects attitudes and adherence to schedules	3	4
Weekly safety checks, safety briefings are superficial	3	4
Subcontractors must sign contracts acknowledging their awareness of safety requirements	4	4
Making time for comprehensive safety trainings	2	2
In need of a assigned on-site safety manager	1	1
Incidents at the workplace sometimes go unreported	1	1

Table 4.7 Worker attitudes and behaviours findings

Worker Attitudes and Behaviours	Different individuals	Times mentioned
Non-compliance with safety requirements driven by inconvenience	9	15
Some workers find it challenging to assess risks effectively.	6	9
Stressed workers may prioritize finishing jobs quickly over safety	6	7
Experienced workers may feel overconfident and underestimate risks	6	6
Better safety practices tend to occur on cleaner construction sites	6	6
Employees exhibit good awareness of safety requirements but do not show it	5	6
Workers tend to assess risks within their specific work areas rather than comprehensively	5	6
Threats from the actions of other workers are not considered	4	5
Peer influence on safety	4	4
Maintaining consistently high safety standards	4	4
Ingrained habits are difficult to change	4	4
Even when safety requirements are followed, accidents can still occur	3	3
Safety inspectors play a vital role in alerting workers to minor hazards and potential dangers	2	2
Younger workers often require more explanation and education about potential risks	1	1
After sustaining injuries, employees may follow safety rules for a brief period	1	1
Fear of injuries lead to compliance of safety regulations	1	1

Table 4.8 Workplace resources and conditions findings

Workplace Resources and Conditions	Different individuals	Times mentioned
Unsecure and missing railings/barriers	7	9
Non-compliance with industry standards for tools and equipment	8	8
Lack of usage of safety equipment even when provided	7	7
Cleaner sites are associated with fewer hazards	6	6
Larger sites are expected to adhere to requirements more strictly.	4	6
Smaller companies lack the necessary resources to comply with safety requirements	3	4
Guards on tools are sometimes removed	4	4
Lack of proper attachment points for safety harnesses	4	4

5 DISCUSSION OF FINDINGS

5.1 Main types and causes of accidents

In order to gain a comprehensive understanding of prevalent workplace accidents and their root causes, an in-depth analysis was conducted utilizing the OSHA database. The comprehensive examination revealed a predominant occurrence of accidents involving the upper and lower limbs, with notable frequencies of injuries to the head and face. Notably, fingers emerged as the most injured body part, followed by legs and knees. The findings further extended to actions contributing to injuries, with a significant proportion linked to movement, hand tools, power tools, climbing, and descending activities.

Delving into the specifics, the OSHA database drew out primary causative factors reported in incidents. The majority of cases involved the violation of occupational safety requirements by the employee, this further divided into several sub-causes. Unsurprisingly, the most frequently cited cause was the non-usage of personal protective equipment, emphasizing the critical role of proper protective gear in injury prevention. The second most prevalent cause highlighted violations of safety regulations by fellow workers, underscoring the shared responsibility for maintaining a safe working environment. A compelling third cause was the non-compliance of the work environment with safety requirements, signalling the need for stringent adherence to safety standards.

Beyond these leading factors, the database identified additional significant contributors to workplace injuries. Insufficient internal workplace safety control emerged prominently, indicative of gaps in internal safety management practices. Inadequate training and guidance constituted another noteworthy factor, emphasizing the pivotal role of comprehensive training programs in fostering a safety-oriented culture. Additionally, the incompatibility of tools surfaced as a key concern, shedding light on the importance of utilizing tools compliant with safety standards.

These findings, drawn from analysis of the OSHA database, not only highlight the common types of workplace accidents and their causes but also offer insights into the nature of these incidents. The focus on fingers as the most frequently injured body part emphasizes the need for additional safety measures, while identifying specific actions contributing to injuries helps in tailoring effective intervention strategies. The recurring issues of not using personal protective equipment and violating safety regulations emphasize the need for more efficient safety protocols and a culture of compliance.

Additionally, the detailed understanding of factors such as internal safety control, training, and tool compatibility serves as a practical guide for enhancing workplace safety measures.

5.2 Observations regarding violations on-site

The on-site observations align closely with the findings from the OSHA database, establishing a clear connection between observed work practices and documented accidents. Notably, non-compliance with regulations in the use of hand and power tools were prevalent during on-site assessments, echoing the OSHA data that highlights a significant number of accidents associated with these tools. The amount of working at heights, falling, and slipping hazards in on-site observations aligns seamlessly with the OSHA database's documentation of accidents in these specific categories.

A concerning observation from the on-site assessments is the consistent pattern of non-compliance with personal protective equipment usage, with gloves emerging as the most frequently overlooked item. This on-site trend aligns directly with the OSHA database, where finger injuries are highlighted as the most common type, reinforcing a strong connection between on-site practices and reported accidents.

On-site assessments reveal a notable frequency of the non-usage of goggles and helmets, in harmony with the OSHA database's identification of injuries related to these personal protective equipment's. These correlations accentuate the need to address these issues at the construction sites, presenting an opportunity to proactively mitigate workplace accidents through targeted interventions.

Another prevalent issue observed on construction sites was the inadequacy of tools, notably the frequent utilization of inappropriate work platforms and ladders. Workers often justified this by citing the absence of better alternatives. Moreover, a troubling trend in safety practices emerged during laying down the parquet, where the removal of guards on power tools was prevalent. This underscores a significant worry about safety culture and priorities, as employees might jeopardize finger safety for the sake of task convenience, possibly indicating a shortage of suitable tools. Effectively addressing these challenges related to equipment compatibility and ensuring the correct usage of tools could help to improve workplace safety within the construction industry.

In addition to this alignment with OSHA data, the on-site observations provide valuable insights into specific construction stages where safety concerns are most prevalent. The

number of remarks and observations on sites in the building completion stages implies that this phase may involve more different work processes and the simultaneous engagement of various workers. It is noteworthy to acknowledge that observed safety violations might only represent a fraction of actual infractions on the site, as certain errors may not have been apparent to the observer.

5.3 Attitude of employees on-site

The interviews with employees underscore that while a substantial portion of the workforce acknowledges the essential nature of personal protective equipment, this recognition often remains a formality. Many individuals cite the desire to expedite work as a common excuse for neglecting personal protective equipment usage, revealing a potential gap between awareness and practical implementation. A noteworthy finding is the prevalent sentiment among workers who have remained incident-free for years, indicating a potential lack of awareness regarding the inherent risks or perhaps an overconfidence in their work.

A significant number of respondents emphasized the discomfort associated with personal protective equipment usage, particularly with gloves, as a prominent reason for non-compliance. The discomfort aspect resonates with the observation that gloves were the most problematic personal protective equipment during on-site assessments, explaining why finger injuries are the most common in the OSHA database. This highlights the need for more ergonomic and comfortable personal protective equipment solutions to improve overall adherence to safety protocols.

Furthermore, some workers justified their lack of personal protective equipment by asserting that their supervisors had not provided the necessary equipment. This raises questions about the organisational culture and the perceived significance of personal protective equipment within the workplace. It prompts considerations about whether supervisors undervalue the necessity of personal protective equipment for their employees, if employees themselves underestimate its importance, or if there is a collective lack of awareness regarding potential risks, resulting in lack of personal protective equipment usage.

5.4 Occupational safety risk matrix

Upon closer examination of the risk analysis findings based on construction managers' evaluations, a notable disparity emerges between their prioritization of safety concerns and the patterns evident in the OSHA database. While construction managers assign the highest risk to working at heights and the potential danger posed by falling objects, this stands in contrast to the OSHA data, where hand and power tools usage, along with welding and cutting activities, take precedence as significant contributors to workplace incidents.

This incongruity prompts a critical inquiry into whether construction managers could benefit from a more comprehensive understanding of the inherent risks associated with specific activities, particularly those prominently featured in OSHA records. It hints at a potential gap in awareness or risk perception, underscoring the importance of aligning managerial risk assessments with the empirical evidence reflected in incident data.

Moreover, the disparity in risk evaluation extends beyond high-risk activities. A striking observation arises in the assessment of falling caused by slips and trips, classified by construction managers as having a moderate risk level. This classification sharply contrasts with the OSHA database, where incidents related to movement on the same level, resulting in slips and trips, exhibit numerical significance.

This incongruence may represent an opportunity for construction managers to recalibrate their risk assessments, considering the actual frequency and impact of incidents in different work scenarios. It underscores the importance of a nuanced and data-driven approach to risk management, where aligning managerial perceptions with empirical evidence can lead to more effective safety strategies, contributing to a safer work environment.

Furthermore, the identified disparities in risk assessment priorities emphasize the need to consider both frequency and severity in evaluating risks. Although construction managers rate working at heights, falling objects, and heavy machinery operations as moderate-risk activities, the OSHA database reveals a lower frequency of incidents in these categories. However, it is crucial to note that when such incidents do occur, the consequences tend to be more severe, emphasizing the importance of a holistic approach to risk assessments.

Additionally, on-site observations highlight specific hazards associated with working at heights, such as inadequately secured harnesses and uncovered openings in elevated floors. This nuanced understanding, considering both the frequency and severity of

incidents, is imperative for construction managers to fine-tune their risk assessments effectively. By aligning their perceptions with the actual data on incident occurrences and outcomes, construction managers can enhance their decision-making processes, tailor safety protocols more precisely, and contribute to an environment that addresses high-risk activities appropriately and mitigates the severity of potential incidents.

5.5 Interviews

5.5.1 Communication and training discussion

Topics related to communication and training emerged as one aspect in ensuring workplace safety, as highlighted by various individuals in the study. Language barriers posed a notable challenge, with communication issues mentioned five times by different individuals. Interviewees mentioned a reliance on managers for workers' knowledge of safety requirements, indicating the need for more effective communication channels between management and workers.

The interviewees provided insights into the implementation of workplace safety inductions, highlighting both positive aspects and areas for improvement. There is unanimous agreement on the importance of conducting safety inductions for everyone entering the site, but it was noted that the current inductions are very general and could benefit from being more job-specific, suggesting an opportunity for enhancement. Additionally, some interviewees expressed that the safety induction process tends to be rushed when the site is busy, implying a potential challenge in delivering comprehensive training during peak times.

The recurrent mention of the importance of making safety inductions visually engaging, coupled with the acknowledgment of language barriers, suggests an opportunity to explore and implement innovative solutions like Afzal, et al., (2021) did in the research about improving communication with 4-dimensional building information modelling and virtual reality technologies (Afzal & Shafiq, 2021).

A need to restrict loud music was brought out by one participant. The rationale behind this suggestion was to ensure that audible alarms could be heard effectively in case of emergencies or to alert workers about potential hazards. This recommendation underscores the importance of maintaining an environment conducive to clear communication and immediate awareness.

Training deficiencies were noted, with three mentions of a lack of training among the workers who do lifting operation and a similar number expressing the need to enhance

managers' knowledge of safety. Managers themselves acknowledged that, despite being responsible for ensuring work safety on the site, they expressed a sense of inadequacy in having received a comprehensive overview of the safety requirements. This highlights a potential gap in the communication and training provided to construction managers regarding safety protocols. A participant highlighted the idea that, since you can study becoming a site manager in university, there could potentially be a valuable addition in the form of a course specifically focused on safety within the context of construction sites.

Some managers highlighted the effectiveness of passive learning as a good method for imparting knowledge to workers. For instance, leaving a safety requirements brochure on the table in the workers' break area was suggested as a way to encourage them to peruse it during, for instance, lunch breaks, utilizing moments of downtime for educational purposes.

Another noteworthy topic that was mentioned twice pertained to training sessions organized by the main contractor. In these sessions, the emphasis would be on demonstrating how proper personal protective equipment functions, elucidating the distinctions between reliable and subpar work gloves, for example.

5.5.2 Compliance and enforcement discussion

The findings related to compliance and enforcement in the workplace reveal a nuanced approach among managers. While there is a preference for fostering open communication over resorting to fines, it is acknowledged that fines are frequently used as a punitive measure, especially in scenarios with a large workforce, where time to address problems may be limited. Despite the use of fines, there is a recognition that fines have a temporary impact, with workers eventually reverting to non-compliance.

Some participants suggest that increasing fines could enhance worker motivation to consistently follow safety rules. Additionally, the practice of removing a worker from work for a day is considered effective, as it serves as both a consequence and a financial deterrent, impacting the worker's earnings for that day and fostering a greater willingness to cooperate the following day.

Accessibility and use of safety equipment present challenges, with observations that despite being accessible, such equipment is frequently forgotten by workers. One interviewee highlighted that workers frequently say that personal protective equipment is available but has been left in the car, and worker did not have time to get it. The

time-consuming and inconvenient nature of safety equipment use further complicates the integration of safety measures into work routines.

The impact of managerial presence on compliance is emphasized, with a recurring observation that apparent compliance diminishes once managers are no longer present. Interviewees mentioned the importance of a zero-tolerance approach to prevent the normalization of safety lapses, reinforcing the need for continuous monitoring and reinforcement of safety measures. A notable trend emerges regarding safety compliance during different project phases, with a consensus that compliance tends to be more robust during the initial stages of a project. As projects progress, the increasing pace and higher worker presence pose challenges for construction managers to ensure continued adherence to safety requirements.

Organisational characteristics such as company size and qualification influence safety prioritization and compliance, with perceptions that safety may not be prioritized in smaller or less qualified companies. The role of foreign workers is also discussed, with indications that they may follow safety regulations less diligently, possibly due to cultural or communication barriers. Competent workers tend to adhere to safety regulations more consistently was mentioned by two participants. Age is briefly mentioned in relation to safety compliance, with the observation that younger workers tend to be more effective in adhering to safety requirements.

5.5.3 External and environmental factors findings

The interview findings shed light on external and environmental factors on safety considerations within the construction industry. One salient revelation is the recurring mention of the perpetual time pressure experienced in construction projects. This recurring theme underscores a shared concern among interviewees about the challenges of maintaining comprehensive safety measures amidst the urgency to meet project deadlines. Striking a balance between operational efficiency and safety emerges as a common thread in these discussions.

Some individuals expressed the view that the safety requirements mandated by the country are excessively strict, suggesting a need for a more lenient approach. On the contrary, others highlighted that the rules are well-established, and adherence to them could likely prevent more accidents. An interviewee emphasized that the requirements are ingrained through past experiences, stating that their necessity is understandable,

possibly implying that these rules are established based on lessons learned from previous incidents.

Interviewees brought out that workers may perceive risks only within the scope of their own tasks and may not fully grasp the simultaneous hazards posed by other ongoing activities on the site. For instance, a painter working indoors may not perceive any immediate risks, but stepping outside, they might be unaware of potential hazards posed by, for example, balcony installers working overhead. This lack of holistic awareness among workers highlights a potential limitation in their safety mindset, emphasizing the need for broader safety education and awareness.

The findings illuminate a positive correlation between clean construction sites and improved safety regulation compliance. This suggests that maintaining an organized work environment can contribute to heightened awareness and adherence to safety measures, reflecting the interconnectedness of physical orderliness and a robust safety culture. One interviewee highlighted that even though personal protective equipment was frequently overlooked, at least the site was kept clean because falls and tripping incidents would have slowed down work.

The impact of market forces on safety considerations were also brought out, with 4 mentions indicating that the market may not consistently prioritize attention to safety requirements. This observation underscores the collective responsibility of industry stakeholders to align economic considerations with a steadfast commitment to safety.

The challenges posed by tight schedules and lower budgets, particularly in comparison to neighbouring countries, prompt discussions around resource constraints and the imperative for innovative solutions. The findings emphasize the need for collaborative efforts to enhance safety practices without compromising project timelines or financial constraints.

5.5.4 Management and supervision findings

Interviews reveal several noteworthy findings regarding management and supervision in the context of safety practices within construction sites. One prominent observation is the recurring need for repeated reminders to reinforce safety practices. This emphasizes the importance of consistent communication and reinforcement to ensure that safety protocols are ingrained in the daily operations of construction sites. During the interviews, it became evident that many managers have developed a very similar system for addressing violations of safety regulations. Specifically, a three-level warning

system is in place, where initially, the worker is spoken to directly, then on the second occasion, the problem is raised through the worker's supervisor, and on the third instance, a fine is imposed, the three-level warning approach provides a structured approach to addressing safety issues.

Communicating with subcontractor managers to enhance safety practices emerged as another key aspect, which underscores the significance of collaboration and effective communication between different stakeholders to promote a culture of safety across all levels of the construction project. The participants also brought out the impact of management directives on safety compliance. Clear safety directives from higher-level managers were mentioned 7 times, and managers setting the example received 7 mentions as well. This suggests that managers recognise that leadership plays a crucial role in influencing safety practices, with a top-down approach proving effective in improving compliance at construction sites.

Concerns about the expense of standard safety equipment were also brought up, indicating that financial considerations can pose a challenge to the implementation of robust safety measures. If subcontractors do not have sufficient resources to provide safety equipment, workers cannot adhere to the requirements. This was particularly emphasized in the case of painting companies, where it was mentioned that often the workers are foreigners, and their supervisors have not provided them with personal protective equipment or the appropriate platforms for carrying out their work.

Upper management visits on site encouraging site cleanliness and the impact of often-seen safety inspectors on safety compliance both point to the positive influence of regular monitoring and oversight. These findings suggest that a visible and proactive approach to safety management, both from leadership and external inspectors, can contribute to better adherence to safety protocols.

One manager revealed a gap in incident reporting, as incidents at the workplace sometimes went unreported. This situation indicates problematic management where there is a lack of value placed on incident reporting, potentially leaving the injured workers without compensation related to workplace injuries.

5.5.5 Worker attitudes and behaviours findings

The interview findings shed light on a variety of worker attitudes and behaviours in the context of safety compliance within the construction industry. One prominent theme is the challenge posed by non-compliance with safety requirements, often driven by the

inconvenience perceived by workers. This attitude, mentioned 15 times, reflects a significant concern within the workforce. Moreover, the findings identify that some workers struggle to assess risks effectively. Workers tend to focus on risks within their specific work areas rather than comprehensively. Research by Salo, et al., (2017) stated that people can focus completely on the task they are working on and get so-called selective attention, but the focus of attention changes when something unexpected happens or when changes occur in the environment. (Salo et.al., 2017) Hence, the marking of work areas on construction sites is deemed necessary, as without it, workers may not readily notice potential hazards. Managers pointed out that threats from the actions of other workers are usually not adequately considered.

Stress emerges as a factor influencing worker behaviour, with some individuals prioritizing job completion over safety when under pressure. This finding aligns with existing literature on the impact of stress on decision-making in high-risk environments (Launder & Penney, 2023). Additionally, the overconfidence of experienced workers and their tendency to underestimate risks highlight the importance of ongoing training and awareness programs, even for seasoned professionals.

The role of peer influence in safety practices is another noteworthy finding, emphasizing the importance of a collective approach to promoting and enforcing safety measures. Workers may be more likely to adopt safe practices if their peers prioritize and model such behaviour. A study made in the healthcare industry focused on methods of identifying a peer leader that influences others the most and fostering strong connections with key individuals could lead to improved adherence to safety protocols across the entire workforce (Hurtado, Dumet, Greenspan, & Heinonen, 2018). Although

Managers mentioned that construction involves skilled labour, and many workers have been practicing their profession for several years, and thus have developed ingrained habits that are difficult to change. This underscores the challenge of behavioural change initiatives. This finding supports the importance of implementing long-term strategies and interventions to create a sustainable safety culture within the industry.

5.5.6 Workplace resources and conditions findings

The findings from the workplace resources and conditions reveal several key issues that need attention. The most frequently mentioned concern is the presence of unsecured and missing railings/barriers, with seven individuals highlighting this as a significant problem on nine occasions. Two interviewees mentioned that railings are often installed

for appearance's sake, and they are frequently left unsecured or missing the necessary three boards. In many instances, the toe board is forgotten, and its absence poses a risk of accidentally pushing materials over the edge with one's foot. Another notable issue is the non-compliance with industry standards for tools and equipment, emphasized by eight individuals on eight occasions.

The data also underscores a disconcerting trend regarding the lack of usage of safety equipment even when provided. Seven individuals raised this concern on seven occasions, suggesting a gap in employee awareness or a potential lack of enforcement. The information provided by the managers corresponds to the notes made during site observations and the answers received from the employees. Effectively conveying to workers that their health takes precedence over the speed or convenience of work is crucial. Educating them on the significance of using provided safety equipment and consistently reinforcing compliance measures plays a vital role in mitigating workplace hazards.

The findings also illuminate the challenges encountered by smaller companies, with three individuals expressing their lack of necessary resources to adhere to safety requirements on four occasions. This underscores the importance of providing tailored support and resources to assist smaller enterprises in meeting safety standards and cultivating a secure work environment. Interviewees also mentioned that, typically, they can temporarily provide personal protective equipment, helmets are usually available in the site offices, and the presence of harnesses was also noted.

5.6 Site-safety culture assessment according to Hudson's ladder

Previously, it was briefly mentioned that Hudson's Ladder (Hudson, 2007) is one method for assessing workplace safety culture. In order to evaluate the current level of workplace safety culture on sites based on the results, the different levels of the ladder are firstly explained in more detail.

5.6.1 Hudson's ladder levels

To better illustrate the Hudson's Ladder levels, a visual representation is provided in Figure 5.1.

Pathological level - At this level, safety is often neglected, and there might be a lack of awareness or concern for basic safety measures. The organisation may not prioritize safety, leading to an environment where accidents and hazards are more likely to occur due to a disregard for fundamental safety protocols.

Reactive level - In a reactive safety culture, safety measures are implemented in response to incidents or breaches. Corrective actions are taken after problems occur. While there is a response to incidents, the focus is primarily on addressing issues that have already happened rather than proactively preventing them.

Calculative level - The calculative level involves having safety rules and procedures in place, but there might be a gap in consistently following and enforcing them. The organisation may have a framework for safety, but there is room for improvement in terms of ensuring that these safety measures are consistently applied in daily operations.

Proactive level - At the proactive level, organisations make intentional efforts to prevent incidents through systematic approaches. Safety is integrated into daily practices, and there's a culture of continuous improvement. This level is characterized by a proactive mindset that seeks to identify and address potential hazards before they lead to accidents.

Generative level - The generative level represents the highest level of safety culture. Safety is not just a set of rules but an integral part of the organisation's culture. There is a commitment to providing resources for safety, supporting proactive approaches, and fostering a positive safety mindset at all levels. Organisations at this level actively seek ways to improve safety beyond compliance, considering it a shared responsibility of everyone in the organisation.
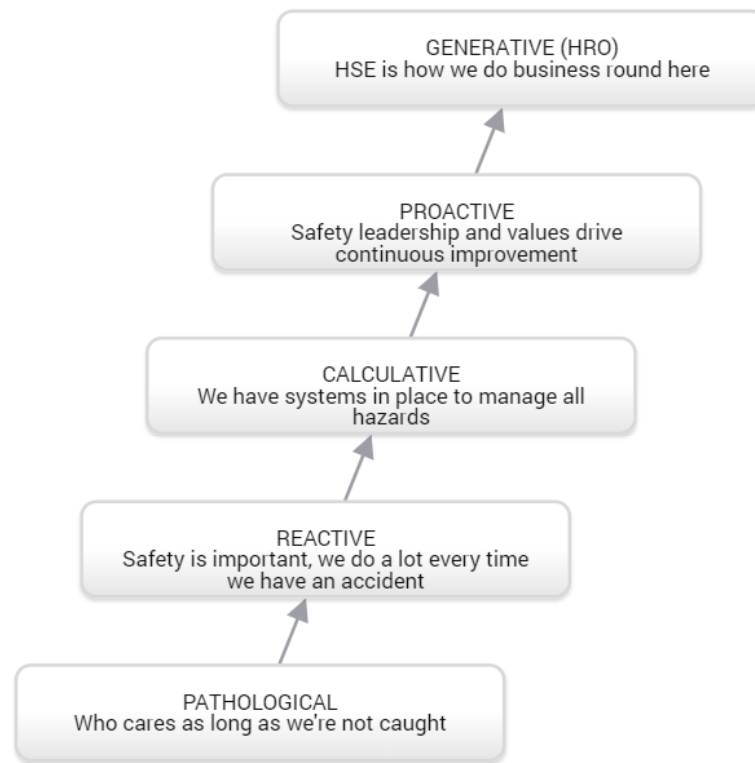
Figure 5.1 Hudson's Ladder of safety (Hudson, 2007)

5.6.2 Distribution of results on Hudson's ladder levels

The pathological level of safety culture is evident in the frequent non-usage of personal protective equipment and violations of occupational safety requirements, leading to injuries. There is a tendency for apparent compliance only when managers are present, indicating a lack of genuine commitment to safety. PPE is often considered inconvenient and unnecessary, contributing to its neglect and forgetfulness. Workplace incidents occasionally remain unreported, reflecting a negligent attitude towards incident reporting and investigation. This behaviour is consistent with the pathological level of safety culture.

Work safety inspections are viewed as superficial, conducted merely for procedural checkboxes rather than a sincere commitment to identifying and mitigating risks. Safety is not a priority in smaller or less qualified companies was brought out frequently, and there is a notable trend of reduced safety compliance among foreign workers. The construction industry operates under constant time pressure, leading to task-specific safety compliance and a lack of attention to broader safety requirements.

Moreover, the frequent mention of market dynamics, including tight schedules and lower budgets, discourages a focus on safety compared to neighbouring countries. While employees may possess an awareness of safety requirements, their actions do not reflect this awareness, indicating a gap between knowledge and practical application. Non-compliance with industry standards for tools and equipment, and deliberate alteration of tools, further exemplify the pathological safety culture, emphasizing a lack of adherence to established safety norms.

The reactive level of safety culture is characterized by addressing issues after they occur and responding to problems rather than preventing them. Challenges related to communication and superficial training arising from language barriers are dealt with after miscommunication incidents happen, indicating a reactive approach. Currently, there are no established methods for construction managers to effectively communicate safety requirements when there is a language barrier, highlighting a lack of proactive measures.

Training gaps are identified after they are noticed, rather than proactively preventing them, suggesting a reactive stance toward skill development. Fines are used as a punitive measure for non-compliance, representing a reactive approach to dealing with safety violations after they have occurred.

During the initial phases of a project, compliance with safety measures tends to be higher, as managers have more time for oversight and control. The importance of cleanliness in construction sites is recognized, with clean sites correlating with improved safety regulation compliance, but this awareness may come reactively after incidents.

Reinforcing safety practices requires repeated reminders, reflecting a need for ongoing corrective actions. Upper management visits are seen as encouraging site cleanliness, but this involvement may occur reactively rather than proactively. The presence of a safety inspector is noted to impact safety compliance, emphasizing a reactive reliance on external oversight. Communicating with subcontractor managers to improve safety practices suggests a collaborative approach to enhancing the overall safety culture in different project tiers. However, subcontractors often prioritize safety only in response to management directives, reflecting traits associated with the reactive safety culture level.

The calculative level of safety culture is evident in several proactive measures and systematic approaches to safety management. While there is recognition of the necessity for visually engaging safety briefings, highlighting the importance of effective communication in conveying safety information, it is noted that many participants still

do not have access to such briefings. Making safety requirement information sheets available indicates a proactive effort to provide comprehensive safety guidelines and resources.

Open communication is preferred by managers over fines, suggesting a preference for constructive dialogue and collaboration in addressing safety issues. The practice of sending a worker home for non-compliance with safety requirements reflects a calculative approach to enforcing safety measures and ensuring immediate corrective actions.

The acknowledgement that permitting safety violations even once can result in persistent non-compliance underscores a proactive mindset toward preventing recurring safety issues. However, the fact that fewer participants mentioned this aspect suggests that it may not be widely implemented or emphasized. The implementation of a three-level warning system mentioned by most interviewees suggests a systematic approach to addressing safety violations with escalating consequences, promoting accountability. Requiring subcontractors to sign contracts acknowledging their awareness of safety requirements demonstrates a calculative emphasis on clearly defining and communicating safety expectations at the contractual level.

The proactive level of safety culture is characterized by measures that go beyond compliance and aim to prevent incidents before they occur. Organizing specific training sessions to show the importance of proper work tools and work clothes exemplifies a proactive approach to enhancing awareness and understanding of safety measures among workers however this was mentioned only by two interviewees.

Managers recognize that clear safety directives from higher-level managers contribute to enhanced compliance at construction sites. This approach ensures that expectations are clear and understood throughout the organisation, promoting a proactive safety culture. However, it's worth noting that some interviewees reported a lack of these directives, indicating a potential gap in the proactive approach to establishing and communicating safety guidelines from top management.

The understanding that safety inspectors are essential for notifying workers about minor hazards and potential dangers reflects a proactive approach to continuous monitoring and early intervention in addressing potential risks before they escalate. This highlights the pivotal role of safety professionals in fostering a proactive safety environment. It's important to note that while some interviewees recognized the significance of safety professionals, others overlooked this aspect, and a few expressed discontent with the frequency and effectiveness of safety professionals' site visits.

The generative level of safety culture - No specific findings were identified that fit the characteristics of the Generative level.

5.6.3 Assessment of results on Hudson's ladder levels

The overall safety culture appears to be predominantly at the reactive level of safety culture. This is evidenced by the reactive approach to addressing safety issues after they occur, the reliance on fines as a punitive measure for non-compliance, and the identification of training gaps after they are noticed rather than proactively preventing them. The emphasis on addressing challenges related to communication and superficial training, after incidents happen further, supports a reactive stance.

While there are elements of the calculative level, such as the acknowledgement of the need for visually engaging safety briefings and the preference for open communication over fines, they seem to be less pervasive compared to the reactive characteristics.

The proactive level is represented by measures such as specific training sessions to emphasize the importance of proper work tools and work clothes, clear safety directives from higher-level managers, and recognition of the role of safety inspectors. However, these proactive measures appear to be mentioned by fewer participants or may not be consistently implemented across the surveyed managers.

5.7 Recommendations

Improving the safety culture requires an approach that considers the actions of all parties involved. There is no one-size-fits-all solution, one of the key areas of emphasis should be on transforming the mindset of construction workers. Adherence to safety requirements must go beyond mere compliance to please managers, rather the importance should be genuinely understood by everyone. The shift in the mindset of construction workers can be facilitated by supportive subcontractor leaders who prioritize safety over prevailing financial considerations.

In terms of education and awareness, next to a proper safety briefing regular safety training sessions should be developed and conducted to address the specific risks and to show the importance of safety equipment. The use of multimedia tools, such as videos and interactive modules, can enhance the engagement and accessibility of safety education.

Site managers need to prioritize safety, influenced by the organisational culture set by their superiors, where safety is valued equally with profitability. Managers could be enrolled in certified safety training programs and tailoring workshops to enhance safety leadership skills. A supportive culture from top management encourages a collective shift toward prioritizing safety. Balancing profitability with a commitment to safety should not only be reflected in policies but also in the attitudes of managers who understand the paramount importance of the well-being of their workforce.

Future research could delve into the specific contexts surrounding safety practices at different construction stages, as many interviewees indicated a correlation between the construction phase and a decrease in compliance with safety regulations. Further investigation could explore the composition of the workforce in various construction phases, considering factors such as nationality and their potential impact on safety practices.

An in-depth investigation comparing construction project management in Finland and Estonia could uncover insights into the observed research gap. Examining project management methodologies, industry regulations, and cultural influences in both countries, along with detailed analyses of scheduling, budgeting, and resource utilization practices, would provide a comprehensive understanding. Interviews or surveys with industry professionals and regulatory authorities in both nations would offer firsthand perspectives, contributing valuable insights for improvement and potential best practices sharing between the neighbouring countries.

Another interesting topic would be to do an ethnographic study on construction workers to investigate the background of workers who do not adhere to safety requirements. Delving into the personal and professional lives of these individuals could uncover nuanced insights into the correlation between safety compliance and income disparities. By exploring their incomes, economic status, and education levels in the context of daily work experiences, the study could provide a qualitative understanding of the factors influencing non-compliance.

CONCLUSION

In the course of the research, various factors influencing safety culture on construction sites were examined. Different methods were employed to assess safety culture, and an attempt was made to understand the state of safety culture on Estonian construction sites through the use of qualitative and quantitative research methodology by using the OSHA database, on-site observations, and interviews with managers.

The study examined accident types and causes on construction sites, analysed factors influencing safety culture, evaluated managers' risk assessment practices, and investigated management actions and attitudes towards safety. Key elements of safety culture, including leadership commitment, employee commitment, open communication, continuous learning, and accountability were introduced. Hudson's Safety Ladder was used to assess the safety culture level on sites.

OSHA database results show that frequent accidents involve the upper and lower limbs, fingers get injured the most. Violations of safety regulations, in particular non-compliance with personal protective equipment, were found to be the main causes. On-site observations closely aligned with OSHA's data, highlighting non-compliance issues with hand and power tools and personal protective equipment usage.

Interviews with employees and managers provided insights into attitudes and behaviours, revealing a gap between awareness and practical implementation of safety measures. Notable problems included language barriers, discomfort with personal protective equipment, neglect of safety equipment and unsafe work practises. External factors such as time pressure and market dynamics pose significant challenges and require coordinated efforts to balance economic considerations with a commitment to safety.

Communication and training emerged as critical components in fostering workplace safety, safety inductions were considered essential, but improvements in visual engagement of said trainings were suggested. Concerns about the expense of safety equipment and incidents going unreported indicated potential gaps in safety management. Non-compliance, ineffective risk assessment, and the influence of stress was often mentioned by managers. Peer influence emerged as a strong factor, emphasizing the collective approach needed for promoting safety.

The Hudson's Safety Ladder assessment shows that the safety culture on Estonian construction sites is mainly on the reactive level. This conclusion is based on the observation that workers follow safety protocols mainly when managers are around. Limited attention is paid to safety requirements and some managers admitted that they only superficially monitor the requirements. While there were also aspects that indicated the calculative and proactive Huddson's Safety Ladder level, these were mentioned less frequently, suggesting that these elements and techniques are used less.

Enhancing safety culture within the construction sector requires a comprehensive strategy, encompassing the shift in worker attitudes, the promotion of safety education, and finding a balance between profitability and safety priorities. The involvement of subcontractor leaders, conducting safety training sessions, and implementing certified safety programs can contribute significantly. Future investigations should delve into diverse construction phases, workforce demographics, and cultural factors. A comparative analysis of project management approaches between neighbouring countries and the economic conditions of non-compliant workers can offer valuable perspectives for further enhancement.

KOKKUVÕTE

Uurimustöö käigus vaadeldi tegureid, mis mõjutavad ehitusplatside tööohutuse kultuuri. Tööohutuse kultuuri hindamiseks kasutati erinevaid meetodeid ning püüti mõista millises olukorras on hetkel Eesti ehitusplatside tööohutuse kultuur kvalitatiivse ja kvantitatiivse uurimismetoodika abil, kasutades selleks Tööinspektsiooni andmebaasi, platsi vaatluseid ja intervjuusid ehitusjuhtidega.

Uurimustöös käsitletakse ehitusplatsidel esinevate õnnetuste tüüpe ja põhjuseid, analüüsiti tööohutuse kultuuri mõjutavaid tegureid, uuriti, kuidas ehitusjuhid riske hindavad, milline on juhtide ja töötajate suhtumine ja käitumine tööohutusega seoses. Lisaks tutvustati tööohutuse kultuuri elemente, sealhulgas juhtkonna pühendumust, töötajate pühendumust, avatud suhtlust, järjepidevat õppimist ja vastutust, Huddsoni tööohutus redeli mudelit kasutati tööohutuse kultuuri taseme hindamiseks ehitusplatsidel.

Tööinspektsiooni andmebaasi tulemused näitavad, et enim juhtuvad õnnetused üla- ja alajäsemetega, eelkõige sõrmedega. Tööohutuse nõuete rikkumine, eriti isikukaitsevahendite mittekasutamine, tuvastati peamisteks õnnetuste põhjusteks. Kohapealsed vaatlused kinnitasid Tööinspektsiooni andmeid, tuues välja kitsaskohti käsi- ja elektritööriistade ning isikukaitsevahendite kasutamisel.

Intervjuud ehitustööliste ja -juhtidega andsid ülevaate suhtumistest ja käitumismustritest, tuues välja lünki tööohutuse teadlikkuse ja ohutusmeetmete rakendamiste osas. Välja toodud probleemid hõlmasid keelebarjääre, isikukaitsevahendite ebamugavust ja ebaturvalisi tööpraktikaid. Intervjuude käigus toodi välja, et välised tegurid nagu ajapuudus ja üldine ehitusturg ei soodusta tööohutusnõuete järgimist.

Avatud suhtlust ja vastavate koolitusete läbiviimist pidasid juhid oluliseks tööohutuse edendamisel. Tööohutusinstruktaaži läbiviimist peetakse oluliseks, kuid toodi välja, et kui materjalid oleksid visuaalsemad jõuaks informatsioon töötajateni paremini kohale. Muret tekitasid kulutused ohutusvarustusele ja juhtumite raporteerimata jäämine, mis näitas võimalikke puudusi tööohutuse kultuuris juhtimise tasandil.

Hudsoni ohutusredeli abil hindamisel selgus, et tööohutuse kultuur Eesti ehitusplatsidel on peamiselt reaktiivsel tasemel. See järeldus põhineb täheldusel, et töötajad kipuvad järgima tööohutuse protokolle, ainult siis kui juhid on lähedal. Ohutusnõuetele pööratakse tähelepanu siis kui aega jääb üle ning osades intervjuudest jäi kõlama, et nõudeid järgitakse ainult pealiskaudselt. Kuigi esines ka elemente ja tehnikaid, mis

viitavad Huddsoni ohutusredeli kalkuleerivale ja proaktiivsele tasemele, mainiti neid harvemini, viidates sellele, et neid elemente ja tehnikaid kasutatakse vähem.

Tööohutuse kultuuri parandamiseks ehitussektoris on vaja terviklikku strateegiat, mis hõlmaks töötajate suhtumise muutmist, tööohutuse alaste teadmiste parandamist ja tasakaalu leidmist kasumlikkuse ja tööohutuse vahel. Edaspidised uurimused võiksid süveneda ehitusetappidesse ning vaadelda kuidas eri etapis tööohutusnõuetega arvestatakse, lisaks võiks vaadata ka tööjõu demograafiasse ja kultuurilistesse teguritesse. Selleks, et ehitussektorit parendada võiks eelkõige teha võrdleva uurimuse Eesti ja naaberriikide vahel, et vaadata kuidas mujal on leitud tasakaal tööohutuse, ajagraafiku ja projekti eelarve osas.

LIST OF REFERENCES

Abdallah, A. A., Shaawat, M. E., & Almohassen, A. S. (2023). *Causes of miscommunication leading to project delays and low work quality in the construction industry of Saudi Arabia.* Retrieved from https://www.sciencedirect.com/science/article/pii/S2090447923003362

Afzal, M., & Shafiq, M. T. (2021). *Evaluating 4D-BIM and VR for Effective Safety Communication and Training: A Case Study of Multilingual Construction Job-Site Crew.* Retrieved from https://www.researchgate.net/publication/353463385_Evaluating_4D-BIM_and_VR_for_Effective_Safety_Communication_and_Training_A_Case_Study_of_Multilingual_Construction_Job-Site_Crew

Al-Bayati, A. (2022). *Construction Safety Culture and Climate: The Relative Importance of Contributing Factors.* Retrieved from https://www.researchgate.net/publication/358280837_Construction_Safety_Culture_and_Climate_The_Relative_Importance_of_Contributing_Factors

Al-Bayati, A. J. (2021). *Firm Size Influence on Construction Safety Culture and Construction Safety Climate.* Retrieved from https://ascelibrary.org/doi/full/10.1061/%28ASCE%29SC.1943-5576.0000610

Arzahan, I. S., Ismail, Z., & Yasin, S. M. (2022). *Safety culture, safety climate, and safety performance in healthcare facilities: A systematic review.* Retrieved from https://www.sciencedirect.com/science/article/pii/S0925753521004641

Battaglia, M., Frey, M., & Passetti, E. (2014, 05 28). Accidents at Work and Costs Analysis: A Field Study in a Large Italian Company. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4243021/

Bell, J. L., Collins, J. W., Wolf, L., Grönqvist, R., Chiou, S., Chang, W.-R., . . . Evanoff, B. (2009). *Evaluation of a comprehensive slip, trip and fall prevention programme for hospital employeesFootnote.* Retrieved from https://www.tandfonline.com/doi/full/10.1080/00140130802248092?casa_token=nrgShPohkOEAAAAA%3A2lB9Olun4Iuwl7To_SF3MIlzDPXyrwV12daebkE_pyeA2jO8Z6jnRFCsQB3a0FTIdgGwsoSQghiQ

Boysen, P. G. (2013). *Just Culture: A Foundation for Balanced Accountability and Patient Safety.* Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3776518/

Brauer, R. L. (2006). *Safety and health for engineers.* Tolono, Illinois: John Wiley & Sons, Inc.

Casey, T., Griffin, M., Harrison, H. F., & Neal, A. (2017). *Safety Climate and Culture: Integrating Psychological and Systems Perspectives.* Retrieved from https://www.researchgate.net/publication/313267042_Safety_Climate_and_Culture_Int egrating_Psychological_and_Systems_Perspectives

Christian, M. S., Bradley-Geist, J. C., Wallace, C., & Burke, M. (2009). *Workplace Safety: A Meta-Analysis of the Roles of Person and Situation Factors.* Retrieved from https://www.researchgate.net/publication/26762637_Workplace_Safety_A_Meta-Analysis_of_the_Roles_of_Person_and_Situation_Factors

Clarke, S. (2006). *The relationship between safety climate and safety performance: A meta-analytic review. Journal of Occupational Health Psychology, 11(4), 315-327.* Retrieved from https://www.researchgate.net/publication/6737387_The_relationship_between_safety_c limate_and_safety_performance_A_meta-analytic_review_Journal_of_Occupational_Health_Psychology_114_315-327

Cooper, M., & Phillips, R. (2004). *Exploratory analysis of the safety climate and safety behavior relationship.* Retrieved from https://www.sciencedirect.com/science/article/pii/S0022437504000878

Cox, S., & Cheyne, A. (2000). *Assessing safety culture in offshore environments.* Retrieved from https://www.sciencedirect.com/science/article/abs/pii/S0925753500000096?via%3Dihu b

Creswell, J. W. (2013). *Research design.*

EUROSTAT. (2023, 10 05). *Fatal Accidents at work by NACE Rev. 2 activity*. Retrieved from https://ec.europa.eu/eurostat/databrowser/view/hsw_n2_02/default/table?lang=en

Filho, A. P., Andrade, J. C., & Marinho, M. M. (2009). *Safety Culture in Petrochemical Companies in Brazil.* Retrieved from https://www.researchgate.net/publication/251911323_Safety_Culture_in_Petrochemical _Companies_in_Brazil

Grissinger, M. (2014). *That's the Way We Do Things Around Here!* Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4029118/

Gu, J., & Guo, F. (2022). *How fatigue affects the safety behaviour intentions of construction workers an empirical study in Hunan, China.* Retrieved from https://www.sciencedirect.com/science/article/pii/S0925753522000248

Han, B., Son, S., & Kim, S. (2021). *Measuring Safety Climate in the Construction Industry: A Systematic Literature Review.* Retrieved from https://www.mdpi.com/2071-1050/13/19/10603

Huang, Y.-H., & Yang, T.-R. (2019). *Exploring On-Site Safety Knowledge Transfer in the Construction Industry.* Retrieved from https://www.mdpi.com/2071-1050/11/22/6426

Hudson, P. (2007). *Implementing a safety culture in a major multi-national.* Retrieved from https://www.sciencedirect.com/science/article/pii/S0925753507000227?casa_token=9Pa_m6mhznMAAAAA:8qQEWHzBfunv5W5qJp4xIIMU7D_7Jx82FlHAt8mS0JaKeAF0xvjmsVWCOHMMdsxECWFzf6g7Yw

Hurtado, D. A., Dumet, L. M., Greenspan, S. A., & Heinonen, Y. I. (2018). *Identifying Safety Peer Leaders with Social Network Analysis.* Retrieved from https://link.springer.com/article/10.1007/s41542-018-0026-4

Int J Environ Res Public Health. (2020). *National Library of Medicine.* Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7663096/

Jeelani, I., & Gheisari, M. (2021). *Safety challenges of UAV integration in construction: Conceptual analysis and future research roadmap.* Retrieved from https://www.sciencedirect.com/science/article/pii/S0925753521003167

Jeschke, K. N. (2022). *Understanding how managers balance the paradoxical nature of occupational safety through a practice-driven institutional lens.* Retrieved from https://www.sciencedirect.com/science/article/pii/S0925753521004677

Karakhan, A. A., & Ahmed, A.-B. (2023). *Identification of Desired Qualifications for Construction Safety Personnel in the United States.* Retrieved from https://www.researchgate.net/publication/370646384_Identification_of_Desired_Qualifications_for_Construction_Safety_Personnel_in_the_United_States

Kineber, A. F., Antwi-Afari, M. F., Elghaish, F., Zamil, A. M., & Alhusban, M. A. (2023). *Benefits of Implementing Occupational Health and Safety Management Systems for the Sustainable Construction Industry: A Systematic Literature Review.* Retrieved from https://www.researchgate.net/publication/373292814_Benefits_of_Implementing_Occu

pational_Health_and_Safety_Management_Systems_for_the_Sustainable_Construction_

Industry_A_Systematic_Literature_Review

Kostovicova, D., & Knott, E. (2020). *Harm, change and unpredictability: the ethics of interviews in conflict research.* Retrieved from

https://journals.sagepub.com/doi/full/10.1177/1468794120975657

Launder, D., & Penney, G. (2023). *Towards a common framework to support decision-making in high-risk, low-time environments.* Retrieved from

https://onlinelibrary.wiley.com/doi/full/10.1111/1468-5973.12487

Mokarami, H., Alizadeh, S. S., & Pordanjani, T. R. (2019). *The relationship between organizational safety culture and unsafe behaviors, and accidents among public transport bus drivers using structural equation modeling.* Retrieved from

https://www.sciencedirect.com/science/article/pii/S1369847819300440

Neal, A., & Griffin, M. A. (2006). *A Study of the Lagged Relationships Among Safety Climate,.*

NFA.dk. (2019). *Det Nationale Forskningscenter for Arbejdsmiljo*. Retrieved 10 24, 2023, from

https://nfa.dk/da/Vaerktoejer/Sporgeskemaer/Safety-Climate-Questionnaire-

NOSACQ50

Osei-Asibey, D., Ayarkwa, J., Acheamong, A., Adinyra, E., & Amoah, P. (2021). *An Examination of Causes of Accidents and Hazards in the Ghanaian Construction Industry.* Retrieved from

https://www.scirp.org/%28S%28vtj3fa45qm1ean45vvffcz55%29%29/journal/paperinfo

rmation.aspx?paperid=110029

Probst, T. M., & Estrada, A. X. (2010). *Accident under-reporting among employees: Testing the moderating influence of psychological safety climate and supervisor enforcement of safety practices.* Retrieved from

https://www.researchgate.net/publication/44663588_Accident_under-

reporting_among_employees_Testing_the_moderating_influence_of_psychological_safet

y_climate_and_supervisor_enforcement_of_safety_practices/citations

Rahman, M. A., Karmaker, C. L., Ahmed, T., Khan, M. I., Morshed, A. M., & Ali, S. M. (2022). *Modelling the causes of boiler accidents: implications for economic and social sustainability at the workplace.* Retrieved from

https://www.sciencedirect.com/science/article/pii/S2405844022008891

Ranasinghe, U., Tang, L. M., Harris, C., Li, W., Montayre, J., Almeida Neto, A., & Antoniou, M. (2023). *A systematic review on workplace health and safety of ageing construction workers.* Retrieved 11 07, 2023, from https://www.sciencedirect.com/science/article/pii/S0925753523002187

Riigikogu. (1999). *Töötervishoiu ja tööohutuse seadus.* Retrieved from https://www.riigiteataja.ee/akt/111032023098

Saldaña, J. (2013). *The coding manual for qualitative researchers.* Retrieved from https://emotrab.ufba.br/wp-content/uploads/2020/09/Saldana-2013-TheCodingManualforQualitativeResearchers.pdf

Salo, E., Salmela, V., Salmi, J., Numminen, J., & Alho, K. (2017). *Brain activity associated with selective attention, divided attention and distraction.* Retrieved from https://www.sciencedirect.com/science/article/pii/S0006899317301361?via%3Dihub

Schein, E. H. (2004). *Organizational culture and leadership.* Retrieved from http://www.untag-smd.ac.id/files/Perpustakaan_Digital_2/ORGANIZATIONAL%20CULTURE%20Organizational%20Culture%20and%20Leadership,%203rd%20Edition.pdf

Shin, I., Oh, J.-B., & Yi, H. K. (2011). *Workers' Compensation Insurance and Occupational Injuries.* Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3431898/

Shringi, A., Arashour, M., Golafshani, E. M., Dwyer, T., & Kalutara, P. (2023). *Enhancing Safety Training Performance Using Extended Reality: A Hybrid Delphi–AHP Multi-Attribute Analysis in a Type-2 Fuzzy Environment.* Retrieved from https://www.mdpi.com/2075-5309/13/3/625

Steinmann, B., Klug, H. J., & Maier, G. W. (2018). *The Path Is the Goal: How Transformational Leaders Enhance Followers' Job Attitudes and Proactive Behavior.* Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6281759/

Syed-Yahya, S. N., Idris, M. A., & Noblet, A. J. (2022). *The relationship between safety climate and safety performance: A review.* Retrieved from https://www.sciencedirect.com/science/article/pii/S002243752200113X

Zhang, L., Liu, Y., & Chu, Z. (2023). *The Influence Mechanism of Owners' Safety Management Behavior on Construction Workers' Safety Citizenship Behavior.* Retrieved from https://www.researchgate.net/publication/373532394_The_Influence_Mechanism_of_Owners'_Safety_Management_Behavior_on_Construction_Workers'_Safety_Citizenship_Behavior

Zohar, D. (2000). *A Group-Level Model of Safety Climate: Testing the Effect of Group Climate on Microaccidents in Manufacturing Jobs.* Retrieved from https://www.researchgate.net/publication/12371675_A_Group-Level_Model_of_Safety_Climate_Testing_the_Effect_of_Group_Climate_on_Microaccidents_in_Manufacturing_Jobs

Zohar, D. (2010). *Thirty years of safety climate research: Reflections and future directions.* Retrieved from https://www.sciencedirect.com/science/article/pii/S0001457509003339?via%3Dihub

Tappura, S., Jääskeläinen, A., & Pirhonen, J. (2022). *Creation of satisfactory safety culture by developing its key dimensions.* Retrieved from https://www.researchgate.net/publication/361284253_Creation_of_satisfactory_safety_culture_by_developing_its_key_dimensions

Tezel, A., Dobrucali, E., Demirkesen, S., Kiral, & Ates, I. (2021). *Critical Success Factors for Safety Training in the Construction Industry.* Retrieved from https://www.mdpi.com/2075-5309/11/4/139

Tööinspektsioon. (2022). *Tööohutus ehitusplatsil, 2022 EST.* Retrieved from https://www.ti.ee/ennetus-ja-teave/infomaterjalid/trukised

Tööinspektsioon. (2022, 11 21). *Tööõnnetuse uurimine*. Retrieved 11 07, 2023, from https://www.tooelu.ee/et/117/tooonnetuse-uurimine

Tööinspektsioon. (2022). *Tööõnnetused 2014-2021.* Retrieved 01 26, 2022, from https://www.ti.ee/asutus-uudised-ja-kontaktid/statistika

Tööinspektsioon. (2023, 09 29). *Tööelu*. Retrieved from https://www.tooelu.ee/et/79/riskianaluus

Valluru, C. T. (2022). *The subcontractor safety problem: hidden, variable, and outsider work Thesis Type.* Retrieved from https://www.researchgate.net/publication/372545722_The_subcontractor_safety_problem_hidden_variable_and_outsider_work_Thesis_Type#fullTextFileContent

Wilpert, B., & Itoigawa, N. (2001). *Safety Culture in Nuclear Power Operations.* CRC Press. Retrieved 23 11, 2023, from https://books.google.ee/books?hl=en&lr=&id=H-BQRictQAMC&oi=fnd&pg=PA94&dq=While+profit+is+a+vital+financial+driver,+prioritizing+it+over+safety+can+negatively+impact+the+culture.+This+can+lead+to+cost-cutting+measures+that+compromise+safety,+such+as+reduc

Wu, G., Wu, Y., Li, H., & Dan, C. (2018). *Job Burnout, Work-Family Conflict and Project Performance for Construction Professionals: The Moderating Role of Organizational Support.* Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6313469/

Yari, S., Naseri, M. H., Akbari, H., Shahsavari, S., & Hesam, A. (2019). *Interaction of Safety Climate and Safety Culture: A Model for Cancer Treatment Centers.* Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6825785/

Yukl, G. (1981). *Leadership in organizations.* Retrieved from http://www.mim.ac.mw/books/Leadership%20in%20Organizations%20by%20Gary%20Yukl.pdf.No1fvHJjqGHg1RgmjuyjD0oYNhx7MNeo

APPENDIX 1

Please fill the table below with numbers 1-5 stating what is the likelihood of an accident occurrence and severity of the accidents impact. A legend is provided below as well.

1. Very Low Risk - Minimal likelihood of occurrence and negligible consequences.
2. Low Risk - Low likelihood of occurrence and relatively minor consequences.
3. Moderate Risk - Moderate likelihood of occurrence with noticeable consequences.
4. High Risk - High likelihood of occurrence and significant consequences.
5. Very High Risk - Extremely likely to occur with severe consequences.

Nr.	Category	Likelihood of occurrence	Severity of impact
1.	Fall caused of slips, trips		
2.	Falling objects		
3.	Electrical hazards		
4.	Fire and explosion		
5.	Heavy machinery operations		
6.	Welding and cutting		
7.	Ergonomic risks		
8.	Noise and vibration		
9.	Working at heights		
10.	Hand and power tools		
11.	Respiratory hazards		
12.	Excavation and Trenching		
13.	Lifting and Rigging		
14.	Incoordination on site		