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Safety Performance in The Maintenance, Repair, Alteration and Addition (RMAA) Sector of The Construction Industry

Reviewed through literature, interviews, statistics and legal assessments

Master Thesis for TBA4930 – Real Estate and Property Management

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Abstract

Between 2014 and 2018 the Norwegian construction industry recorded the fourth highest serious accident rate, and the second highest number of serious accidents among 14 industries classified by Statistisk sentralbyrå (SSB). The *repair, maintenance, alteration and addition* (RMAA) sector constitutes a large part of the construction industry, but it tends to be somewhat overlooked by investors and decision makers. Several sources claim that RMAA workers are susceptible to more accidents – both severe and less severe ones – than production workers within the construction industry. This thesis tries to answer whether this is the case in Norway. Another goal of the research has been to find out whether there are particular aspects of RMAA work that has a clear potential for improved safety performance. The findings of this thesis are inconclusive as regard to these goals. Interviews with RMAA representatives revealed that they generally seemed happy with the current state of safety in their work. It should be noted that three fatal accidents were mentioned during the interview, but that all had occurred during production work – not during RMAA work. Neither were statistical assessments able to confirm or discard whether RMAA work is more dangerous than production work; as Norwegian accident statistics are not categorized in a way that makes it possible to separately assess safety performance in the two sectors. Some economic assessments have also been performed in this thesis to create incentives for decision makers and investors to consider the RMAA sector more thoroughly; and the sector is indeed more important economically speaking, than it is visible. Germany and Great Britain (GB) have produced separate statistics of annual monetary output ascribed to RMAA work and the output ascribed to production work. Unfortunately, this distinction is not used for the economic statistics of the Norwegian construction sector. Under-reporting of occupational accidents is an extensive problem in many countries, but indications exist that the problem may be worse in Norway (where estimates have been made that 77,5% of all occupational accidents go unreported) than in many other nations, including Denmark (45%) and Sweden (>70%). However, even when accounting for the high relative number of unreported accidents, the Norwegian construction industry's safety performance compares favourably to many countries, including Denmark; and similar to Sweden. All interviewees highlighted strict laws and regulations as one of the main reasons for this success. Consequently, arbeidsmiljøloven has been reviewed, and has indeed been found to give little leeway for unsafe business practices, regardless of it is RMAA- or production work being performed.

Abstract in Norwegian

Mellom 2014 og 2018 rapportert den Norske bygge- og anleggsnæringen den fjerde høyeste ulykkesraten for alvorlige arbeidsulykker, og nest flest alvorlige arbeidsulykker totalt, av 14 industrier klassifisert av Statistisk sentralbyrå (SSB). Arbeid i forbindelse med reparasjon, vedlikehold, drift og renovasjon (RMAA) utgjør en stor del av den totale bygge- og anleggsindustrien, men blir ofte til en viss grad oversett av investorer og beslutningstakere. Flere kilder hevder at RMAA-arbeidere er utsatt for et høyere antall skader – både alvorlige og mindre alvorlige – enn det produksjonsarbeidere i bygge- og anleggsindustrien er. Denne oppgaven prøver å besvare hvorvidt dette faktisk er tilfellet i Norge. Et annet mål med oppgaven har vært å se om det er spesifikke aspekter ved RMAA-sektoren med klare forbedringspotensialer med tanke på sikkerhetsytelse. Funnene i denne oppgaven er uklare i så måte. Intervjuer med RMAA-representanter avdekket at de generelt var godt fornøyd med dagens situasjon med tanke på sikkerhet. Det bør bemerkes at tre dødsfall ble nevnt i intervjuene, men at alle disse skjedde i forbindelse med produksjonsarbeid – og altså ikke i forbindelse med RMAA-arbeid. Heller ikke statistiske vurderinger har kunnet bekrefte eller avkrefte at RMAA-arbeid er farligere enn produksjonsarbeid; fordi skadestatistikken ikke er kategorisert på en måte som gjøre det mulig å vurdere sikkerhetsytelsen til de to sektorene separat. Noen vurderinger av økonomisk statistikk er også foretatt for å gi investorer og beslutningstakere insentiver til i høyere grad å prioritere RMAA-sektoren; og sektoren er definitivt viktigere økonomisk sett, enn den er synlig. Tyskland og Storbritannia (GB) har produsert separat statistikk for årlig økonomisk produksjon både for RMAA-arbeid og for produksjonsarbeid. Dessverre er det ikke gjort tilsvarende separering av de to sektorene i den norske statistikken for økonomisk produksjon i bygge- og anleggsbransjen. Underrapportering av arbeidsulykker er et stort problem i mange land, men det eksisterer indikatorer på at situasjonen muligens er verre i Norgen (hvor det har blitt estimert at 77,5% av arbeidsulykker ikke rapporteres) enn i mange andre land, inkludert Danmark (45%) og Sverige (>70%). Selv medregnet denne høye underrapporteringen presterer Norge bra i forhold til mange, inkludert Danmark; og ganske likt med Sverige. Alle intervjuobjektene fremhevet et strengt lovverk som mye av årsaken til den relativt gode situasjonen in Norge. På grunn av dette har også arbeidsmiljøloven blitt gjennomgått, og det er tydelig at loven gir lite spillerom for farlig praksis på arbeidsplassen, uavhengig av om det er RMAA- eller produksjonsarbeid det dreier seg om.

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List of Abbreviations

ACA	Australian Constructors Association
aml.	Arbeidsmiljøloven (abbreviation is only used in tables)
AT	Arbejdstilsynet (statistical agency in Denmark)
AV	Arbetsmiljöverket (statistical agency in Sweden)
DIW	Deutsches Institut für Wirtschaftsforschung (statistical agency in Germany)
EHS	Environment, Health and Safety (not to be confused with HSE)
EU	European Union
EU-OSHA	European Agency for Safety and Health at Work
EUR	Euro (currency)
GB	Great Britain (England, Scotland and Wales)
GBP	Pound Sterling (currency)
HSE	Health and Safety Executive (not to be confused with EHS)
LCC	Life Cycle Cost
MOM	Management, Operation and Maintenance
ONS	Office for National Statistics (statistical agency in the UK)
RMAA	Repair, Maintenance, Alteration and Addition
SSB	Statistisk sentralbyrå (statistical agency Norway)
UK	United Kingdom (GB plus Northern Ireland)

1. Terminology

This chapter is dedicated to presenting definitions and interpretations of the most fundamental terms used in this thesis. Most of these definitions and interpretations were originally written for previous assignments (Johansen 2019a, Johansen 2019b) and they are primarily presented in the same way as they appeared in these assignments; although some are slightly altered. Whether previously used or not, all text is the original work of the writer of this thesis. The terms are presented alphabetically.

1.1. Terms and definitions

Accident rates: Refers to the occurrence of accidents relative to the number of workers within an industry. In this thesis, the rate is expressed as number of accidents per 1 000 workers, unless otherwise specified. Accident rates will be specified for both serious- and non-serious injuries where data is available. The European Union's (EU) publicly available database (Eurostat 2019) used for this thesis, only includes serious injuries (see 'Serious- and non-serious injuries' paragraph) in its statistics of non-fatal injuries. Total accident rates refer to the sum of the serious- and non-serious rates. The words accident and injury are used interchangeably throughout this thesis.

Maintenance: The standard NS-EN 13306 defines maintenance as a 'combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function' (Standard Norge 2017, p.8). Furthermore, maintenance is often distinguished into two types:

- *Corrective maintenance*, or sometimes referred to as 'reactive maintenance' is maintenance to restore a system from a failed or defective state to a working one.
- *Preventive maintenance*, is maintenance carried out at predetermined intervals according to prescribed criteria intended to reduce the probability of failure of a system. Preventive maintenance is generally assumed safer for all parts involved (Milczarek and Kosk-Bienko 2010)

Maintainability: NS-EN 13306 defines maintainability as the 'ability of an item under given conditions of use, to be retained in, or restored to, a state in which it can perform a required function, when maintenance is performed under given conditions and using stated procedures and resources' (Standard Norge 2017, p.17).

Management, Operation and Maintenance costs: Management costs are costs that apply whether the building is operational or not, including taxes and fees, insurances and administrational costs. Operation costs include costs in conjunction with the day-to-day oversight of technical systems (including maintenance which incurs due to failures, defects and vandalism), cleaning, security services and energy consumption. Maintenance costs are the costs of planned maintenance operations.

Production work: Within the construction industry, production work refers to the work taking place in the production phase of construction projects. i.e. the actual construction of a building or construction project. In this thesis, the term does not apply to renovation, refurbishment or upgrades in/of buildings.

RMAA: A term used to coin the maintenance sector of the construction industry. The term applies to renovation, refurbishment and upgrades in/of buildings, as well as to maintenance activities.

Safety culture/climate: The term 'safety culture' gained widespread recognition mostly due to the International Atomic Energy Agency's (IAEA) (1986) report on the Chernobyl nuclear accident (Cox and Flin 1998; Pidgeon 1998). In organizational science, the words culture and climate are sometimes used interchangeably, despite distinct etymology (Schneider and Reichers 1990; Cox and Flin 1998). There is some debate of whether the terms can be said to have distinct meanings at all, and some argue that there is no need to separate the two when it comes to safety research. Some of this debate is described in detail by Cox and Flin (1998). This thesis will refer to either word, depending on which is used in the sources of the context.

Serious- and non-serious accidents: This thesis uses Statistisk sentralbyrå (SSB) and Eurostat's (2018) definition of serious accidents as accidents leading to work absence for more than three days (effectively four days or more), while non-serious accidents are accidents leading to work absence for three days or less, including cases that do not lead to any absence (SSB 2019a). SSB includes fatal accidents in its statistics for serious accidents (SSB 2019a), while such is not the case in Eurostat's (2019) and Arbetsmiljöverket's (AV) (2020) statistics. The terms serious- and non-serious accidents may also be referred to as long- and short term absence accidents.

Sustainability: This thesis recognizes the meaning of the term, *sustainability*, or *sustainable development*, as it is defined by Brundtland et al. (1987, p.1) in the second chapter Our Common Future: '*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*'

Furthermore, it is common to treat sustainability as a concept of three fundamental dimensions, often called, *the three pillars of sustainability*. These three pillars represent the *economic-*, *environmental-* and *social* aspects of sustainability. Sustainability cannot be achieved without all three of these aspects being sustainable on their own (Brundtland et al. 1987). Purvis, Mao and Robinson (2018, p.681) suggest that there is no single point of origin for this conception, but rather that it has gradually emerged ‘*from various critiques in the early academic literature of the economic status quo from both social and ecological perspectives on the one hand, and the quest to reconcile economic growth as a solution to social and ecological problems on the part of the United Nations on the other*’. It Is important taking into consideration that the three dimensions are interlinked, and that they do impact one another. Figure 1 is taken from this publication, and shows three popular ways of visualizing the three-pillar concept.

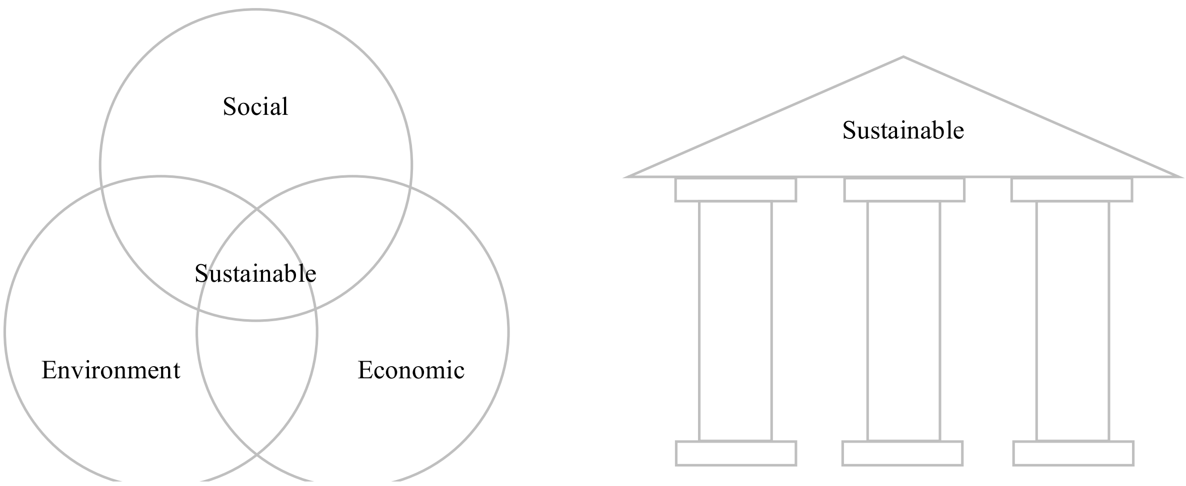

Figure 1: Two different models used to visualize the three pillars of sustainability. Source: Purvis, Mao and Robinson (2018)

1.2. Additional considerations when reading

References to tables from other sources: This thesis frequently refers to statistical tables used in other sources. Whenever such tables are referred to – rather than those within this thesis – the word *table* and the respective tables’ *names* or *numbers* are written in *italics*, to avoid confusion as to which table is actually referred to.

Workers – employees, hired workforce and employers: Worker is a more general term than employee, as it refers to employees, hired workforce and employers. Statistical sources sometimes refer the term employees rather than workers. Unless the source specifically specifies that employers are not included in its statistics, it is assumed that it applies both to employers and employees. Therefore, this thesis generally uses the term worker, rather than employee when referring to these sources.

2. Introduction

The construction industry is plagued by a high number of occupational accidents compared to most other industry sectors, both in terms of the total number of accidents and in terms of accident rates (e.g. Industry Profiles n.d; SSB 2019d; Eurostat 2019; U.S. Bureau of Labor Statistics 2019; Labour Department 2019). Between 2014 and 2018 the Norwegian construction industry ranked between second to fifth worst for serious accidents rates among 14 industries classified by SSB, and between second to third worst for total number of serious accidents Not surprising perhaps, considering the complexity of construction projects; characterized by their unique nature, as enterprises being built on-site over a long time-span and with many partners involved. What may be surprising however, is that the tasks of repairing, maintaining and refurbishing buildings are said to be just as dangerous as constructing them. According to the European Agency for Safety and Health at Work (EU-OSHA), both severe- and less severe accidents occur with higher relative frequency during maintenance work than during production work. Another claimed characteristic of maintenance related accidents is that both their causes and their outcomes vary more than occupational accidents in other industry sectors. (OSHWiki contributors 2017)

This thesis investigates the safety of construction work in general, and of RMAA work specifically through interviews, and by reviewing literature and statistics; as well as the Norwegian Act of arbeidsmiljøloven (2005).

The structure of this thesis is as follows:

- Chapter 1: Terminology - Definitions and interpretations of the most fundamental terms used in this thesis.
- Chapter 2: Introduction – This chapter.
- Chapter 3: Methodology – The chapter describes the methodology that has been used in order to answer the research questions.
- Chapter 4: Literature Review – Relevant literature is presented and structured in subsections.
- Chapter 5: Interview Findings – The findings from the interviews are presented.
- Chapter 6: Statistics – Accident statistics from different countries are assessed. Simple algorithms have been developed and used to make data comparable.
- Chapter 7: Legal Sources Regulating Safety at Work – Includes an assessment of Arbeidsmiljøloven.
- Chapter 8: Conclusion – Conclusions are presented. The research questions are answered.
- Chapter 9: Discussion and Suggestions for Further Research – This chapter includes a critical view on this thesis itself, and suggestions for further work and research.

3. Methodology

This master thesis is a continuation of a literature review project (Johansen 2019b) that was submitted for the project course, TBA4501 – Real Estate and Property Management in 2019. The literature review project was inspired by parts of exercise number EUF 3.05 (corresponding to EUF 5.09 in 2020) (NTNU 2020), but only by parts of it. Merely as a clause, the exercise text mentions that statistically, maintenance workers are more prone to injuries than production workers. Upon agreement with the project supervisor, it was decided that the assignment should mainly focus on the safety aspects of RMAA work, thereby diverging from the original intent of exercise EUF 3.05.

The scope of the literature review is quite broad, and includes information that is not mentioned in other chapters of the thesis. The broad scope did however help to establish an understanding of trends and possible aspects of improvement within the construction industry in general, and the RMAA sector specifically. And although further investigations did not necessarily indicate a clear correlation between these trends or aspects, and safety performance; it is not to say that no such correlation exists, just that the research conducted for this thesis has not found any.

A qualitative interview guide with 23 questions – largely based on the knowledge attained when writing the literature review –was prepared both in Norwegian and in English. However, all participants were fluent Norwegian speakers, and only the Norwegian version were used for the interviews. An informational letter was also prepared, describing matters relating to privacy, consent, rights to withdraw statements, etc. Eleven requests to participate in interviews were sent to six construction companies involved in RMAA activities. Some of which are also involved in the production phase of the industry. The requests to partake were sent by email. Six requests were sent using contact information provided by the project supervisor. The rest of the requests were sent using contact information provided by the interviewees. Out of the eleven requests sent, five were replied (45% response rate), and four interviews were conducted (36% participation) with four different companies, three of which are public ones. One of the companies employed less than 50 workers, while the other three employed several hundreds. The one respondent not partaking in an interview was willing to do so, but was not able to participate before after it was decided that the interview assessments should be completed. All four interviewees had high ranking positions as Deparment Managers of management, operation and maintenance (MOM) sections within their respective companies. None of them are directly involved in refurbishment activities, as such work is the responsibility of other sections within the their companies. Three out of the interviewees (interviewee number 1, 2 and 4) had previous professional background as certificated craftsmen, and one (interviewee number 3) had previously held administrative positions within public authorities. All interviews were conducted in April 2020.

Large parts of this thesis are statistical assessments; mostly of accident statistics, but a review of economic statistics is included as well. All statistical assessments are presented in chapter 6. Several statistical databases and documents from several countries or regions have been used for these assessments. The accident statistics assessments are mainly based on statistics from Norway's SSB, Denmark's Arbejdstilsynet (AT), Sweden's Arbetsmiljöverket (AV) and EU's Eurostat. For the economic assessments, the main statistical sources are Germany's Deutsches Institut für Wirtschaftsforschung (DIW) (2011), and the UK's Office for National Statistics (ONS) (2020), as these sources present economic output that can be directly attributed to RMAA activities. This is way of categorizing statistics is important to highlight the importance om the RMAA sector, which tends to be somewhat neglected by investors and decision makers (Hon, Chan and Yam 2014; Chan and Hon 2016). References to statistical data from other countries or regions are made as well, but the most detailed assessments are from those just mentioned. Correspondences with statistical agencies via email have also contributed to the information presented in the statistics chapter. These communications have involved guidance on how to use the respective databases; information about their statistical classifications; and how statistics are collected. To present comparable accident statistics data for Scandinavia (excluding Finland, as explained in section 6.3), several adaptions and calculations had to be performed, due to the statistics being presented differently in Denmark than it is in Norway and In Sweden. These adjustments constitute a large part of the presented assessments, as comparing the Scandinavian countries was considered very important when reviewing occupational safety performance in Norway. The statistical assessments are presented in statistics chapter.

The contents of the Act of Arbeidsmiljøloven has also been reviewed due to all interviewees highlighting its importance for the relatively good safety performance of the Norwegian construction industry. The legal assessments are presented in chapter 7.

4. Literature Review

Parts of this chapter contains text that was used in the assignment submitted for the TBA4501 project course (Johansen 2019b).

4.1. Safety Culture

Safety is defined in the Oxford English Dictionary as ‘the state of being protected from or guarded against hurt or injury’ (“safety, n.” 2020); while Merriam-Webster defines it as ‘the condition of being safe from undergoing or causing hurt, injury or loss’ (“Safety.” 2020). One can perhaps say that occupational safety is achieved if workers leave their jobs in in the evening in the same healthy condition as they entered work in the morning. While these definitions might seem overly simplistic, they are useful in the way that are easily understood across a wide range of etymologies. Gherardi, Nicolini and Odella (1998, p.202) conclude that ‘people in organizations do not learn “safety”; rather, they learn safe working practices’. Furthermore, the publication describes safety as a term that is understood differently depending on the specific practices where it is used, and that it is ‘controlled by the community that arises around these practices’. As such, what is determined as an acceptable level of hazard will differ between countries and cultures.

According to the United Kingdom (UK) Government agency, Health and Safety Executive (HSE) (2002), it is widely accepted that human behaviour is a contributing factor in approximately 80% of work related accidents. The report states that this has caused some confusion of how to effectively improve upon environment, health and safety (EHS) issues, with some claiming further advancements mainly to rely on contributions from each individual worker. However, HSE (2002, p.38) proposes that ‘perceiving the problem as “within the employee” limits the identification of effective solutions’. Furthermore, Hofmann and Stetzer (1998) suggest that post-accident investigations tend to focus on finding individuals to blame, rather than fully investigating the accidents’ underlying causes. These views are much in line with publications like e.g. HSE (1999); Garavan and O’Brian (2001); Barling, Loughlin and Kelloway (2002); and Mullen (2004). Barling, Loughlin and Kelloway (2002) also found safety specific transformational leadership to positively affect workers’ safety climate perception, thereby directly linking organizational factors to safety performance. Mullen (2004) suggests that many such organizational factors, in addition to job design and engineering systems, are likely to be overlooked if accident investigators are extensively focused on finding scapegoats.

While most literature on the subject seem to agree that organizational culture merits attention when assessing safety performance, Cox and Flin (1998) stresses the importance of using hard data for evaluating its actual significance, and it is suggested that without a sound theoretical framework of definitions and measures, the whole concept of safety culture is at risk of becoming worthless.

Furthermore, the publication claims much of the research on the topic to be vague in character, with little hard facts to support its conclusions. Pidgeon (1998) seconds these claims, while adding that the concept of safety culture imposes several dilemmas. Perhaps the most fundamental one, Pidgeon argues, arises because of the role in which culture influences our world-views, and our perception of what is important and what is not. This is much in line with Gherardi, Nicolini and Odella's (1998) conclusion that the conception of safety is both situationally- and culturally dependent. A culture can function *positively* as a mechanism illuminating important issues; but it can also *negatively* impact situations by turning attention away from other ones, or even by generating poor routines and attitudes. This proposes a challenge in the work of structuring research on safety culture, and perhaps in structuring research at all – on one hand, one should try to be as specific as possible to gather hard data and facts; on the other, it is important not to get so hung up in own convictions that one starts to overlook or disregard aspects relevant to the research.

Although speculative, it is possible that the perceived risks of RMAA work are somewhat trivialized compared to the perceived risks of production work, where many risk factors are obvious due to heavy machinery, scaffolds, etc. being visibly present on-site. Hon, Chan and Wong (2010, p.894) suggest that 'one of the root causes of accidents in RMAA works is low safety awareness of RMAA workers', indicating some level of truth to this hypothesis; although the statement does not specify whether the safety awareness of RMAA workers are worse than that of production workers in the construction industry.

4.2. Hazards

EU-OSHA is a decentralized agency of the EU, whose ultimate purpose is to increase work safety by collecting, analysing and communicating EHS information. According to the agency, maintenance workers are often required to remove or dismantle collective protective equipment to complete their tasks, thereby exposing themselves to occupational hazards. As a result, accidents, both severe and less severe ones, occur with higher relative frequency during RMAA work, than during production work. Considering that all physical items or systems need some form of RMAA work to remain functional over time – be it a single bolt that needs to be retightened, or a complete building that is due for refurbishment – it is no wonder that RMAA workers are exposed to a lot of different hazards, depending on what they are maintaining or altering (Milczarek and Kosk-Bienko 2010). This leads to another characteristic of maintenance-related accidents; namely that both their causes and their outcomes vary more than in other professions. Therefore, taking maintainability into account in design and planning processes is a good way to enhance RMAA workers' safety. (OSHWiki contributors 2017)

HSE (n.d.) specifically highlights four issues to be treated with extra precaution when planning and performing maintenance activities:

- **Disturbing asbestos:** although no longer used as a building material in new constructions, asbestos can still be found in many older buildings, and it is very important to take proper precautions if handling asbestos in any way. Failing to do so is both hazardous and expensive in terms of clean-up costs.
- **Falls from heights:** maintenance workers are often required to use access equipment like cranes or scaffolds to reach the parts requiring maintenance. Using properly placed lifting equipment, as well as the necessary safety equipment to avoid falls is very important when undertaking such kind of work.
- **Isolation and permits to work:** Maintenance work should ideally be conducted without any disturbance to the core business of the building. However, this is often not possible, meaning both the maintenance work and the building's core business must be performed alongside each other. Temporary isolation or lock off arrangements are necessary to ensure the safety of all the affected trades.
- **Falls of heavy items:** It is important to clear the zones underneath where the maintenance work takes place to minimize the eventual damages from falling objects or personnel. This zone should also be kept clear of objects that can cause additional harm in the case anyone should accidentally fall.

While precautions like these might seem self-evident, they are frequently downplayed or neglected – and were even more so in the past (Hon, Chan and Yam 2014). Holte, Kjestveit and Lipscomb (2015) points out that that the construction industry is made up of a multitude of occupational trades, and a high share of small businesses with less than 50 employees. According to Hon, Chan and Wong (2010), this is especially true for the RMAA branch of the industry, describing most RMAA projects as small sized contracts, undertaken by small sized contractors. According to a study conducted in France in 2003, about half of all maintenance workers were employed in companies with less than 50 employees (Milczarek and Kosk-Bienko 2010). This information is highly relevant when assessing EHS, as several studies have found a significant inverse correlation between company size and accident frequency (e.g. Fabiano, Currò and Pastorino 2004; Hasle and Limborg 2006). Further complicating the situation is the fact that, by nature, construction projects are both complex (meaning that they involve many contractors and last over a long time-span) and unique (meaning that projects are built on-site and that almost no two projects are perfectly comparable) by nature. Taking all these factors into account, it is easy to understand how EHS work in this sector can be challenging, to say the least.

4.3. Lean Production and the Manufacturing Industry

Statistics and scientific literature suggest that the manufacturing industry compares favourably to construction in terms of safety performance. The concept of lean production – sometimes simply referred to as lean – is by some accredited as one of the reasons for this advantage. While Dahlgaard-Park and Pettersen (2009) expresses concern that the concept does not have a well-established de facto definition, the main idea of it is to streamline production by increasing process control, and by reducing production time and waste. Successful application of lean principles contributes to creating more controlled working conditions (Hoonakker, Carayon and Loushine 2010). Increased control over business processes can also benefit the EHS situation. Some – Landsbergis, Cahill and Schnall (1999) being a notable example – have argued that lean production can lead to increased productivity pressure, introducing incentives to make shortcuts that negatively affects occupational safety. Conti et al. (2006) on the other hand, claims that the problem lies with how some businesses adapt the concept solely to focus on streamlining production and enhancing profits, rather than within the concept itself. Even though lean principles can, and to some extent are used in the construction industry; there are clear distinctions between construction and manufacturing (Hoonakker, Crayon and Loushine 2010); and perhaps the main reason why the manufacturing industry has been more successful at implementing the concept is simply due to it being introduced – on a large scale – as a manufacturing concept by car manufacturer, Toyota in the 1950's (Andersson, Eriksson and Torstensson 2006). However, some lean principles can be traced back to at least 1913, when another car manufacturer, namely Ford, installed the first assembly line at its Highland Park factory (Hu 2013; Sarhan and Fox 2013) Yet, the concept was not labelled as 'lean' before the publication of Womack, Jones and Roos' book, *The machine that changed the world*, in 1990 (Andersson, Eriksson and Torstensson 2006). The challenge of successfully implementing lean production in the construction industry is a reminder that industries vary by nature, and that one cannot necessarily directly apply existing concepts from one industry to another; rather, they must be altered to suit the specific needs and barriers of the new industry for which it is applied (Andersson, Eriksson and Torstensson 2006; Hoonakker, Carayon and Loushine 2010; Sarhan and Fox 2013).

4.4. Measuring Safety Performance

According to Chan and Hon (2016, p.12) 'there are two main types of safety performance measurement indicators, namely lagging [sometimes referred to simply as lag] indicators and leading [sometimes referred to simply as lead] indicators'. Lagging indicators are defined by the Australian Constructors Association (ACA) (2015, p.1) as 'events that have already occurred that cause harm to the people that work in an organisation that are measured as an indicator of safety performance', while leading indicators are defined as 'the proactive measures that organisations undertake to assist in improving their safety outcomes'. Some examples of lagging indicators are: injury frequency and severity, lost number of workdays, and injury compensation costs; whereas examples of leading indicators include: safety training, risk reducing factors, employee perception surveys, and safety audits (Middlesworth 2020). Table 1 lists key differences between the two types, and its content is presented exactly as it appears in ACA's (2015) publication.

Table 1: Lead and Lag Indicators. Key differences between lead and lag indicators. The content of the table is presented exactly as it is by ACA. Source: ACA (2015)

Lead indicators	Lag indicators
Are actionable, predictive and relevant to objectives	Are retrospective, focusing on past behaviours and incidents
Identify hazards before an incident occurs	Identify hazards after an incident occurs
Allow preventative actions before the hazard manifests itself as an incident	Require corrective actions to prevent another incident
Allow response to changing circumstances through implementing control measure before an incident	Indicate that circumstances have changed require control measures to be implemented after the incident
Measure effectiveness of control systems	Measures failure of control systems
Measures inputs and conditions	Measures outcomes
Direct toward and influence a wanted outcome or away from an unwanted outcome	Measure the current outcome without influencing it
Give indications of system conditions	Measure system failures
Measure what might go wrong and why	Measure what has gone wrong
Provide proactive monitoring of desired state	Provide reactive monitoring of undesired effects
Are useful for internal tracking of a performance	Can be useful for external benchmarking
Identify weaknesses through risk control systems	Identify weaknesses through incidents
Are challenging to identify and measure	Are easy to identify and measure
Evolve as organisational needs change	Are static and measure past incidents

Hallowell et al. (2013); ACA (2015); and Chan and Hon (2016) – among others – strongly advocate the usage of lead indicators for improving construction workers' safety, describing them as more effective than lagging indicators for identifying potential hazards. These publications also highlight the preventive nature of leading indicators; how the indicators consider the effectiveness of measures taken; and that they give indications of why something might go wrong. Chan and Hon specifies three main reasons for why lagging indicators are not sufficient for measuring safety performance of RMAA activities: (1) under-reporting of minor injuries, (2) lack of proper activity classifications in the accident statistics, and (3) lack of information on the number of RMAA practitioners.

While accident statistics are defined as lagging indicators, and does not intrinsically function as a preventive measure against accidents; accurate statistical data can be used as a source for determining existing challenges; and as such, it composes important information when assessing which preventive measures can be expected to generate positive EHS outcomes. Consequently, it can easily be argued that lagging indicators play a major role for the successful implementation of leading ones; and that ultimately, many effective leading indicators are developed based on experiences from previous events. As a lot of accident statistics is readily available (although not sufficiently so, as will be discussed in the section 6.8), it has been a major source of information when writing this thesis.

The Norwegian law requires construction businesses to create and utilize EHS guidelines and -frameworks whenever work is to be performed (aml § 3-1). Such guidelines and frameworks may offer important indicators as to what went wrong whenever accidents or unwanted situations occur; and even more importantly, they may help prevent such situations. Statsbygg has provided the author of this thesis with some of the EHS guidlines and -frameworks that they use in their work (personal communication, April 20, 2020). These are attached as appendices A, B, C and D.

4.5. Environmental impact

Although not specifically studied in this thesis, the environmental aspect of sustainability cannot be left unannounced. The global construction sector is rapidly growing, and is projected to continue to do so, with an expected built area of 230 billion square meters in the four coming decades – the equivalent to the area of Paris being built every week for 40 years (Abergel, Dean and Dulac 2017). The overall built environment accounts for approximately half of the worlds CO_2 emissions, and even though energy efficiency in the industry is improving, the relative reduction of energy consumption does not offset the increasing demand for built area; and construction related carbon emissions have increased around 1% each year since 2010. Buildings do of course continue to consume resources their whole life. Power (2008) argues however, that in many cases, carbon reduction can be achieved more effectively by refurbishing existing constructions, instead of demolishing them and building new ones. When refurbishment is not an option, the environmental impact of operating the building must be considered carefully, as Bogenstätter (2000) claims that programming and building specifications of construction projects can determine up to 80% of their environmental performance. With ever increasing concerns of energy- and resource shortages, the world needs to review the necessity of its consumptions, and to consider whether some new construction projects can be abandoned in favour of rehabilitation projects. (Power 2008; Abergel, Dean and Dulac 2017)

The environmental aspects of sustainability can be assessed by considering wastes, emissions and pollutants, and can be quantified using measures like e.g. CO_2 emissions, or electricity consumption. Reduction of built assets' carbon footprint has been the political motivation of many governmental funding initiatives. Perhaps most renowned is the German CO_2-Gebäudesanierungsprogramm, also known as the CO_2 Building Rehabilitation Programme. The program was introduced by the German Government in the late 1990's, and was elongated in 2006, and yet again in 2015 (Bundesministerium für Wirtschaft und Energie (BMWi) 2015), after being reviewed as highly successful. The program has received international praise, and has been the subject of many scientific research projects. The goal of the programme was to bring all pre-1984 building up to contemporary energy efficiency standards within 2020, although the deadline for reaching this milestone has later been postponed to at least 2025. In some cases, projects receiving funds through the programme, have reduced their energy consumption by as much as 80%. (House of Commons, Communities and Local Government Committee (HoC) 2008; Power 2008)

Although not as comprehensive as the German initiative, a similar program exists in Norway through Enova. Enova was established in 2001 and is owned by Klima- og Miljødepartementet. The amount of funding dispensed by the programme is continuously increasing, and so is the number of projects receiving such funds. (Enova 2020; n.d.)

5. Interview Findings

The interview guide (appendices E and F) consisted of 23 questions. Four interviews were conducted with four different businesses involved in RMAA activities. All interviewees held positions as daily managers in their respective companies; out of which three are public ones. Interviewee 3 has a degree from a university/college with previous work experience from administrative positions within public authorities. The other three interviewees (interviewee number 1, 2 and 4) do not have higher educational degrees, but are all certificated craftsmen, with previous work experience as such. The interview transcripts are not included as to avoid sharing sensitive information.

5.1. Consistencies and Inconsistencies Between Interview Answers

In general, the interviewees were answering most questions in a very similar manner, indicating that they share similar experiences and impressions during their time as Department Managers. There were however two questions in particular, that were answered quite differently by interviewee number 3; and interviewee number 1, 2 and 4, which all answered these two questions very similarly as well. *First:* to question of whether the interviewee identified as being part of the construction industry, interviewee number 3 answered that they see themselves as a supportive service provider, but not as part of the construction industry; while the others all answered that they do see themselves as part of the industry. *Secondly*: To the question of whether the interviewees had ever witnessed macho culture posing a threat to EHS, interviewee number 1, 2 and 4 all said that while they had indeed witnessed such situations during their careers, they do not really perceive macho culture as much of a problem today; whereas interviewee number 3 said that they saw macho culture as a recurring phenomenon in the situations where accidents or unwanted events occurred. It did seem however, that some of the reason why the latter of the two questions was answered quite differently, was due to some variation of how the respondents perceived the macho culture term; with interviewee number 3 ascribing it to situations which may perhaps by others be understood simply as incidences of poor- or hasty judgement. This impression was caused by all interviewees describing the cases that triggered unwanted situations, or where accidents had occurred, as caused either by the workers not following established routines, neglecting to take proper precautions, poor communication, or a combination of these. Whereas interviewee number 3 regarded these causes as directly relating to macho culture, the others did not explicitly express the same interpretation of the term. This may indicate that educational background does impact the way that problems are perceived, and possibly also how they are handled. If such is the case, the differences do not necessarily stem from the level- or contents of the education itself: one could also argue that the they are a result of different personalities being drawn towards different kinds of education.

Whatever the reason may be for these differences, it would be an interesting topic for research to investigate whether there is any traceable variation in the safety performance of RMAA undertakings based on the educational background of those managing them. The research conducted for this thesis however, does not in *any* way qualify to indicate whether such performance differences exist – neither does it seek to do so. On a side-note; during personal communication (April 9, 2020) with Eli Grimsby – the daily manager of Kultur- og Idrettsbygg Oslo KF – she stated her impression that currently most RMAA management positions are engaged by highly skilled individuals of craftsmanship background, but that there is increasing interest for getting persons of academic background into such positions as well. It is important to note that *no* mention was made during this conversation that academics are expected to perform better than those of craftsmanship background, regarding the safety of the workers for which they are responsible.

5.2. Injuries

The most severe injuries disclosed during the interviews were caused by falls from heights. Three fatal accidents were mentioned, all of which were caused by the deceased falling from heights; but all three were related to production work, and not RMAA work. The accidents were mentioned by separate interviewees, meaning that none of the interviewees mentioned fatal accidents more than once. Neither did any of the fatal accidents occur during work in which the interviewees were in charge. However, two of the fatal accidents occurred during projects where the interviewees had been working on the same projects as the deceased, although not necessarily in close relation to them. Other serious accidents that were mentioned included electric shocks and cuts from sharp tools. The most severe electric shocks that were mentioned occurred during work on electric switchboards, while severe injuries from cuts were caused by power saws. There were two mentions of dangerous equipment failure. One of these led to a minor injury due to the system being maintained having a defect relating to electrical grounding. The other case involved a failing scaffolding. Luckily, no one was hurt in this case, but such a defect can indeed lead to fatal injuries. Even though no serious injuries had occurred in these situations, they do highlight that faulty equipment may create dangerous situations. One case of MOM workers sustaining chemical injuries was mentioned. The accident was caused by human error, but not on the part of the MOM workers; underlining that whenever several parts are involved, everyone is affecting the safety of one another. None of the interviewees announced to be performing work in proximity to moving parts or systems. No injuries were mentioned from work involving handling of asbestos. The interviewees were not specifically asked about asbestos, but they were asked to provide information about accident causes.

5.3. Harm to Others than Those Associated with RMAA Work

Several cases were also mentioned of others than those associated with the RMAA work, were either injured, or could have been injured because of the work being performed. One of these – which luckily did not end in any persons being harmed – were related to refurbishments work, where scaffolding over the entrance of a building collapsed. Unlike the scaffolding defect already mentioned, this failure was caused by the scaffolding being overloaded, meaning that it was a result of human error. Two cases were users other than the workers did get hurt were also mentioned. One where a person had had been overrun by a delivery truck, and one where a person had taken a fall due to barriers that had not been placed with proper precaution. These cases were also relating to production or refurbishment work, and were not cases in which any of the interviewees had been in charge of the work being undertaken. In most cases where accidents had occurred, the work had been performed by smaller hired contractors, and not by the companies' in-house workforce.

5.4. Maintainability

There were some mentions of maintainability being an issue, due to buildings being poorly designed for future RMAA work to be conducted. Most of these concerned older buildings, but there was one mention of poor maintainability of a newer construction. One interviewee told that in some of the older buildings it performed work on, ventilation ducts are placed on top of each other, making the upper one difficult to reach. In the case involving the newer building, two particular issues were brought up, one of which must be regarded as a direct mistake on the planners' part. This was that the electrical infrastructure of the building was designed incorrectly, frequent imposing unnecessarily laborious situations. The other mention concerning this building; was of a glass bridge between two constructions that is placed several floors above the ground, but without any access points for cranes to be used during maintenance. Whenever performing maintenance work on this glass bridge, tall scaffolding must be assembled.

5.5. EHS Measures and -Frameworks

Each of the interviewees' companies do initiate investigations whenever accidents occur. When the investigators deem it necessary, changes are made to the companies' EHS guidelines and frameworks. Such changes were made after several of the cases mentioned during the interviews. In the case with the overlying ventilation ducts, the interviewee reported that such a design is not allowed on new constructions. After the accident were a person had been overrun, the company involved introduced requirements that deliveries by motor vehicles on any facility's compound shall be done by at least two workers; one driver, and one to lead the way by foot. If the properties' outdoor areas are – for any reason – crowded at specific times of the day, the company does not allow any such deliveries to take place during these hours. A specific safety measure mentioned by another interviewee, was that whenever work is performed in places where mobile signal is poor, it shall be performed by at least two people so that one may summon help should the other be injured. A fourth specific measure that was brought up, was introduced by the interviewee's company after experiencing one of the fatal fall accidents already mentioned in this chapter. In this case, the deceased had lost their helmet, and it was decided that all helmets used by its workers – both its own employees and hired ones – should utilize straps to prevent them from falling off. The deceased might not have survived even if the helmet had been held in place, but strapless helmets were deemed as an unnecessary risk either way. None of the companies accept the use of ladders for lengthy work in the height. All such work is performed using scaffolds or by secured harness equipment. All interviewees indicated that their safety frameworks are comprehensive, implementing both leading and lagging indicators to assess their safety performance.

5.6. RMAA Work vs Production Work

In all the cases where the interviewees had direct knowledge of RMAA workers having been severely injured, the accidents occurred many years ago. All mentions of more resent severe cases concerned incidents that happened during production work, and the injured individuals were predominantly hired workforce. The interviewees' companies are currently mainly hiring by framework agreements with businesses they have good experiences with. The length of the framework contracts varies according to the contents of the work. All interviewees attributed a lot of their safety performance success to the strict Laws of Norway; which demand that businesses create EHS assessments of any work task that might involve danger, and that companies conducting such work, implement frameworks to handle these dangers.

5.7. Other Notable Mentions

Other notable findings from the interviews that does not necessarily directly concern safety matters, and some speculations of the future of the industry includes:

- Vandalism is a problem, and something RMAA workers frequently encounter in their work. Schools are particularly plagued by vandalism. This is something that has to be accounted for when programming building specifications.
- Industrial control systems (ICS) are generally effective for detecting issues, and reduces the need for lengthy troubleshooting.
- Automated construction machines or robots may very well be considered commonplace on future construction sites, and in future RMAA work. If such eventually becomes the case, previously unencountered issues may arise regarding the interaction between humans and machines.

6. Statistics

When writing this thesis, a choice was made to mainly focus on statistics of serious accidents (see definition in section 1.1), as these are the ones assumed to best be reflecting the real threat to RMAA workers' occupational safety; and therefore, the ones which merits the greatest amount of attention. Injuries resulting in work absence of less than three days are thus assumed to be of lesser importance when assessing the main safety issues of an industry. Arguably, this view is overly simplistic, but as time, resources and the authors research experience remain limited, this was considered the most viable way of conducting the research within these limits. This is also the way in which the EU-OSHA focuses its research (OSHWiki contributors 2016). Most of the statistical data presented in this chapter applies for the whole of an industry, rather than for specific sectors within that industry. As RMAA is a sector within the construction industry, few statistics are here presented that specifically addresses RMAA work. The reason for this is that *no* statistical databases, specifically addressing the safety of RMAA work, have been found. Luckily – while still scarce – a bit more statistics have been found, concerning its economic aspects, although this is of course of lesser direct importance when assessing safety matters. It goes without saying that this has been a major issue when trying to clearly answer the research questions of this thesis. Consequently, the thesis is less conclusive, and presents data that are less directly applicable to be answering its research questions, than was initially hoped for. The lack of statistics is discussed in more detail in section 6.8. Still, accident statistics for the whole construction industry are considered to be highly relevant when trying to assess safety information about any of its sectors.

6.1. Compared to Other Industries in Norway

Compared with most industries, construction has a high number of reported serious accidents relative to reported non-serious accidents. From 2014 to 2018, the construction industry reported the fourth to fifth highest (fifth highest on average) number of non-serious injuries; with according accident rates which were the fifth to eighth highest (seventh highest on average) among the 14 industries classified by SSB. At the same time, it was the industry reporting the second to third highest (second highest on average) number of serious injuries; generating serious accident rates that were the second to fifth highest (fourth highest on average) among these industries, in those same years. These statistics can be seen in tables 2 to 5, which – for each year between 2014 and 2018 – show the number of accidents and accident rates for 14 industries in Norway. The superscripted numbers indicate the rank of the construction industry compared to the others, where 1 would indicate it to be the industry with the highest number of reported accidents, or the highest accident rate; and 14 would indicate it to be the industry with the lowest number of accidents, or accident rates.

Table 2: Number of non-serious accidents in the Norwegian construction industry. Total number of reported accidents leading to short term absence from work for 14 industries in Norway between 2014 and 2018. Source: SSB (2019d).

Non-serious accidents – number of reported accidents						
Industry	**2014**	**2015**	**2016**	**2017**	**2018**	**Average**
Agriculture, forestry and fishing	140	162	140	162	160	153
Mining and quarrying	243	248	192	225	234	228
Manufacturing	1 833	1 696	1 458	1 387	1 313	1 537
Electricity, water supply, sewerage and waste management	247	273	252	278	265	263
Construction	(4)**1**	(5)**1**	(5)**1**	(5)**1**	(5)**1**	(5)**1 310**
Wholesale and retail trade: repair of motor vehicles and motorcycles	754	685	745	690	746	724
Transportation and storage	637	829	835	868	908	815
Accommodation and food service activities	175	148	160	177	158	164
Information, financial and professional activities	195	227	248	205	235	222
Administrative and support service activities	524	474	525	497	559	516
Public administration, defence and social security	828	1 455	1 498	1 308	1 561	1 330
Education	1 627	1 568	1 453	1 487	1 636	1 554
Human health and social work activities	4 246	3 664	3 142	3 143	3 339	3 507
Other service activities	145	165	145	146	158	152

Table 3: Number of serious accidents in the Norwegian construction industry. Total number of reported accidents leading to long term absence from work for 14 industries in Norway between 2014 and 2018. Source: SSB (2019d).

Serious accidents – number of reported accidents						
Industry	**2014**	**2015**	**2016**	**2017**	**2018**	**Average**
Agriculture, forestry and fishing	141	199	211	206	214	194
Mining and quarrying	196	171	140	124	131	152
Manufacturing	1 416	1 449	1 209	1 115	1 192	1 276
Electricity, water supply, sewerage and waste management	196	209	232	191	235	213
Construction	(3)**1**	(3)**1**	(2)**1**	(2)**1**	(2)1	(2)**1 383**
Wholesale and retail trade: repair of motor vehicles and motorcycles	719	730	651	691	747	708
Transportation and storage	806	909	862	917	977	894
Accommodation and food service activities	217	204	184	223	207	207
Information, financial and professional activities	204	222	213	236	245	224
Administrative and support service activities	569	609	608	638	703	625
Public administration, defence and social security	332	764	1 064	1 015	1 122	859
Education	707	683	675	632	679	675
Human health and social work activities	2 135	2 260	2 170	2 121	2 258	2 189
Other service activities	166	172	178	171	180	173

Table 4: Non-serious accident rates in the Norwegian construction industry. Number of reported accidents per 1 000 workers leading to short term absence from work for 14 industries in Norway between 2014 and 2018. Source: SSB (2019d).

Non-serious accidents – reported accidents per 1 000 workers						
Industry	**2014**	**2015**	**2016**	**2017**	**2018**	**Average**
Agriculture, forestry and fishing	5,7	5,3	4,4	4,9	4,9	5,0
Mining and quarrying	3,6	3,8	3,3	3,8	3,9	3,7
Manufacturing	8,0	7,0	6,3	6,0	5,5	6,6
Electricity, water supply, sewerage and waste management	8,5	8,7	7,8	8,5	7,9	8,3
Construction	(5)**6,9**	(7)**5,6**	(7)**5,5**	(8)**4,7**	(8)**4,9**	(7)**5,5**
Wholesale and retail trade: repair of motor vehicles and motorcycles	2,2	1,9	2,0	1,9	2,0	2,0
Transportation and storage	4,7	5,7	5,7	6,0	6,2	5,7
Accommodation and food service activities	2,1	1,4	1,5	1,6	1,4	1,6
Information, financial and professional activities	0,7	0,8	0,8	0,7	0,8	0,8
Administrative and support service activities	3,7	3,2	3,4	3,0	3,2	3,3
Public administration, defence and social security	5,6	9,1	9,2	8,0	9,5	8,3
Education	8,4	7,2	6,6	6,6	7,2	7,2
Human health and social work activities	8,8	6,6	5,6	5,6	5,8	6,5
Other service activities	1,9	1,8	1,5	1,5	1,6	1,7

Table 5: Serious accident rates in the Norwegian construction industry. Number of reported accidents per 1 000 workers leading to long term absence from work for 14 industries in Norway between 2014 and 2018. Source: SSB (2019d).

Serious accidents – reported accidents per 1 000 workers						
Industry	**2014**	**2015**	**2016**	**2017**	**2018**	**Average**
Agriculture, forestry and fishing	5,8	6,5	6,6	6,2	6,6	6,3
Mining and quarrying	2,9	2,6	2,4	2,1	2,2	2,4
Manufacturing	6,2	6,0	5,2	4,8	5,0	5,4
Electricity, water supply, sewerage and waste management	6,7	6,6	7,2	5,8	7,0	6,7
Construction	(2)**6,4**	(3)**6,2**	(5)**5,8**	(5)**5,5**	(5)**5,2**	(4)**5,8**
Wholesale and retail trade: repair of motor vehicles and motorcycles	2,1	2,0	1,8	1,9	2,0	2,0
Transportation and storage	6,0	6,2	5,9	6,3	6,6	6,2
Accommodation and food service activities	2,6	2,0	1,7	2,0	1,8	2,0
Information, financial and professional activities	0,7	0,8	0,7	0,8	0,8	0,8
Administrative and support service activities	4,0	4,1	3,9	3,9	4,1	4,0
Public administration, defence and social security	2,2	4,8	6,6	6,2	6,8	5,3
Education	3,6	3,2	3,1	2,8	3,0	3,1
Human health and social work activities	4,4	4,1	3,9	3,8	3,9	4,0
Other service activities	2,2	1,9	1,9	1,8	1,8	1,9

6.2. Compared to the Manufacturing Industry in Scandinavia and the EU

As buildings become more technically advanced, construction projects become increasingly complex. SSB (2018) also points out that the increasing number of labour migration workers adds to this complexity, as foreign workers might not be familiar with Norwegian customs, and because some communication barriers may arise. The increase in complexity has resulted in a productivity decline of almost 10% since year 2000 (SSB 2018). To combat the productivity issue, many researchers have turned their attention toward the manufacturing industry, in hopes that manufacturing methods and concepts can be adapted to improve upon it.

Perhaps even more important than the productivity issues though, is the manufacturing industry's favourable safety performance when compared to that of construction; as statistics suggest that manufacturing workers are less prone to serious occupational accidents than those working construction. This is very evident in the EU statistics, where annual serious accident rates in construction were 43 to 57% higher than the rates in manufacturing from 2011 to 2017 (Eurostat 2019). In Denmark, the relative difference is even higher, with serious accident rates being 75 to 94% higher in construction than in manufacturing between 2015 and 2019 (AT 2020a; 2020b; 2020d). In Norway however, the difference is much less apparent, with the rates in construction being just 3 to 15% higher than in manufacturing between 2014 and 2018 (SSB 2019d). The country with the least difference between the two industries' rates is Sweden; where serious accident rates for construction and manufacturing were equal for each year between 2014 and 2018. It should be made clear however, that AV's (2020a) statistics only show the rates with an accuracy of one decimal: the lowest of all the countries and regions mentioned above. It is worth pointing out that according to these statistics, accidents occur much less frequently within both industries in Norway than in the EU and Denmark, and quite a bit less frequently than in Sweden as well. The construction- and manufacturing industries' serious accident rates are shown for all the three Scandinavian countries and the EU in figure 2, for the years of which they are available. The statistics for Denmark have been processed and calculated as described in section 6.3.

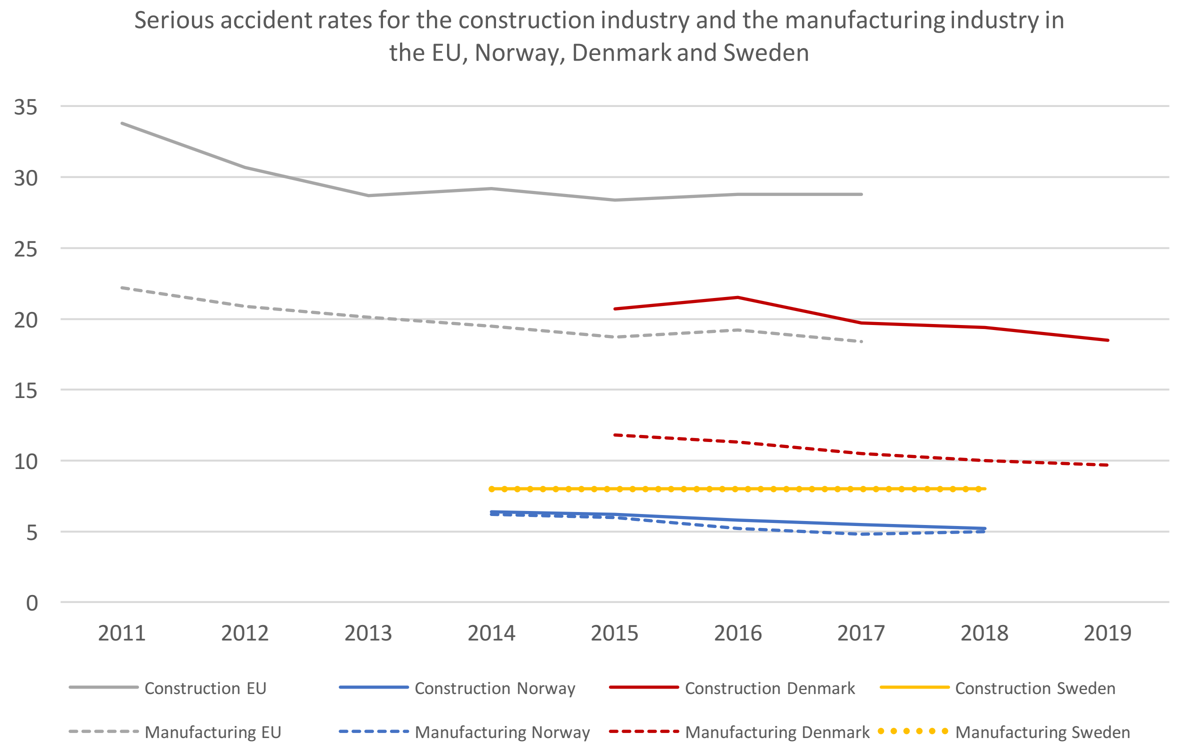

Figure 2: Serious accident rates for construction and manufacturing in the EU, Norway, Sweden and Denmark. Serious accident rates per 1 000 workers in the construction industry and in the manufacturing industry in the EU, Norway, Denmark and Sweden. Source: AT (2020a; 2020b; 2020d); AV (2020a); SSB (2019d); Eurostat (2019) [the statistics for Denmark has been processed as described in section 6.3].

Well in correspondence with what has been claimed in several scientific publications; the European and Danish statistics indicate that the manufacturing industry has outpaced construction in assuring its workers safety. However, the same conclusion cannot clearly be said to hold merit in Norway and Sweden, based on these countries' statistics. If one were to assume that the manufacturing industry represented some kind of benchmark for the highest possible level of safety that could be achieved in the construction industry; the two countries would indeed seem to be approaching that level. This is merely meant as a hypothetical digression, but it should be noted that, in most countries, the statistics *do* suggest the manufacturing industry to outperforms construction in terms of safety performance.

6.3. Adjustments to Create Comparable Statistics

AT in Denmark does not specify the accident rates for accidents resulting in more than three days of absence from work for any industries in any of its statistics. *Table B2* in attachment B (AT 2020d) of AT's 2019 annual report on occupational accidents (AT 2020c), shows the accident rates for what it labels as *alvorlige ulykker*, which directly translates into *serious accidents*. However, the *table* defines serious accidents as accidents leading to work absence of more than three *weeks*, instead of the three days-definition used in the EU, Norway and Sweden. Neither are the industry classifications in the *table* directly comparable to those used by these three countries/regions. Therefore, to compare the statistics of all three countries and the EU, several operations had to be done to calculate accident rates for Denmark that comply with the definition used by the others. This was no small task, but as a Scandinavian country, Denmark's accident statistics are of high value when assessing the safety performance of industries in Norway. Ideally, statistics from all of Scandinavia should be presented in this chapter. However, too little statistical data is available in Finland's publicly available statistical database (Official Statistics of Finland n.d.) to calculate accident rates for the Finish construction industry that are comparable to the others; neither were other databases found that presented such statistics, although it is unlikely that such statistics do not exist.

The first step of doing so, was by finding the number of workers in both the construction industry and the manufacturing industry. *Table B1* in the report's attachment B (AT 2020c) shows the total number of reported accidents and their corresponding accident rates, for 36 (37 if one includes the 'unknown' class) different industry sub-classes. Briefly explained, this means that the statistics are not given for the broader industry classifications used by SSB (2019d; definitions at SSB n.d.) and Eurostat (2019; definitions at Eurostat 2008) such as, construction; mining and quarrying; manufacturing; administration and support service activities, etc.: instead, each industry is divided into several sub-classes. Since accident rates are defined as number of accidents per k number of workers, the number of workers within a sub-class can be calculated using the equation,

$$x_i = \frac{A_i}{r_i} = \frac{A_i}{r_{ki}} \cdot k, \qquad \text{Eq. (1)}$$

where,

x_i is the number of workers in sub-class i,
A_i is the number of reported accidents in sub-class i,
r_i is the accident rate per worker for sub-class i,
r_{ki} is the accident rate for sub-class i per k number of workers,
k is the number of employees for which the rate r_{ki} applies.

Because the accident rates in *table B1* are only accurate to three decimal places, eq. (1) will not yield exact worker numbers. However, provided that no drastic adjustments, of any sort, were made when AT calculated the accident rates for the sub-classes, it was assumed that the equation would yield numbers of sufficient accuracy to calculate accident rates that would adequately illustrate the safety performance of any industry in question. And, as will soon be shown, this did turn out to be the case.

To determine the number of workers within an industry, the sub-classes constituting that industry have to be identified. This can be done by using AT's *Arbejdsulykker, fravær table* (2020b). The *table* does not include accident rate statistics, but it does however classify industries into larger groups that are more similar to those used in the statistics in the EU, Norway and Sweden. The class in the *table* that best represents manufacturing is labelled as *manufacturing and distribution* instead of just manufacturing. By clicking on the industry class one can see which sub-classes it comprises. For manufacturing and distribution these are sub-classes 06-14, 19-20 and 23 in *table B1*. By leaving out sub-class 23 – namely, water supply, sewerage and waste management – these correspond well with the sub-classes that make up the manufacturing industry in the statistics of Eurostat (2008), SSB (n.d.) and AV (2020a). The number of workers within an industry can be calculated using the equation,

$$x = \sum_{i=1}^{n} x_i = \sum_{i=1}^{n} \frac{A_i}{r_{ki}} \cdot k, \qquad \text{Eq. (2)}$$

where,

x is the total number of workers in an industry,

n is the number of sub-classes,

the remaining variables are equal to those used in eq. (1).

An industry's accident rate can then be calculated by the equation,

$$r_k = \frac{A}{x} \cdot k = \frac{\sum_{i=1}^{n} A_i}{x} \cdot k, \qquad \text{Eq. (3)}$$

where,

r_k is the accident rate for an industry per k number of workers,

A is the number of reported accidents in an industry,

the remaining variables are equal to those used in eq. (1) and eq. (2).

Even though AT's *table B1* lacks statistics for most of the broad industry classifications, it does provide such data for the construction industry, as well as for each of its sub-classes. This made it possible to check if application of eq. (1) and eq. (2) would yield worker numbers that, when put into eq. (3), yielded accurate accident rates. Equation (3) can be considered adequately accurate *if* – by using the statistics for the construction industry's sub-classes – it yields approximately the same accident rates that are reported in *table B1* for the industry as a whole. For each year between 2014 and 2019, table 6 compares the construction accident rates that were calculated using eq. (1), (2) and (3), to those given in *table B1*. Table 6 displays the rates as accidents per 10 000 workers (k = 10 000), instead of per 1 000 (k = 1 000), as is generally used throughout this thesis. This is the same *k*-value that is used in *table B1*, and it was deemed that the most logical way of comparing calculated values to existing ones, was by leaving the unit of the original values unchanged. When rounding the calculated rates to the same accuracy as those given in *table B1*, the rates are exactly equal to one another. This means that the three equations, eq. (1), 2 and 3, can indeed be used to calculate accident rates of industries in Denmark, using existing statistical data; and that they are likely the same equations that were used by AT when calculating the rates displayed in the country's official statistics.

Table 6: Calculated and reported accident rates for the Danish construction industry. The rates are calculated using eq. (1), (2) and (3), with input data for the industry's sub-classes – as the data appear in AT's table B1 – compared to the accident rates of the construction industry in the same table, for each year between 2014 and 2019. Source: AT (2020b; 2020d).

	Year					
	2014	**2015**	**2016**	**2017**	**2018**	**2019**
Calculated rates	294,33	314,26	320,71	318,98	325,75	314,33
AT's *table B1* rates	294	314	321	319	326	314
Gap in percentage (from B1 rates)	0,11	0,08	-0,09	-0,01	-0,08	0,10

The remaining step was finding the serious accident rates for the two industries. This was done by subtracting the number of accidents resulting in less than four days of absence from work, from the total number of reported accidents, *A*, for each industry. Reported accidents resulting in an unknown number of days of absence were also subtracted from the total number of accidents, possibly yielding serious accident rates that are slightly lower than the real one. It was assumed though, that the majority of these accidents are of a less serious manner. For the construction industry, all these statistics can be found directly in the *Arbejdsulykker, fravær table* (AT 2020b), for each year between 2015 and 2019. As previously mentioned however, this *table* includes water supply, sewerage and waste management in the statistics for the manufacturing industry. Therefore, yet another *table* had to be used to find serious accident rates for the manufacturing industry. For each year between 2015 and 2019, one can use AT's *Arbejdsulykker, jobtype table* (AT 2020a) to find the number of accidents leading to less than four days of absence, for each of the 36 sub-classes in *table B1*. The two *tables*; *Arbejdsulykker, jobtype* and *Arbejdsulykker, fravær* presents the same number of accidents, granted that the sub-classes chosen in the former corresponds with those of the industries in the latter. The *tables*' accident numbers do however vary slightly from those presented in *table B1*; and the rates were calculated using the total numbers from the former two of the three, i.e., not those presented in *table B1*. For each year between 2015 and 2019, table 7 shows the total number of reported accidents, number of serious accidents, number of workers, and the serious accident rates, for both the construction- and the manufacturing industry in Denmark.

Table 7:Number of accidents, workers and accident rates in the Danish construction industry. Number of reported accident; number of serious accidents; number of workers; and serious accidents rates between 2015 and 2019. Source: AT (2020b; 2020d).

		Year				
		2015	2016	2017	2018	2019
Construction	Total number of accidents	4 817	5 155	5 181	5 423	5 395
	Numbers of serious accidents	3 209	3 473	3 266	3 333	3 269
	Number of workers	155 253	161 332	165 905	171 878	176 832
	Serious accident rates	**20,7**	**21,5**	**19,7**	**19,4**	**18,5**
Manufacturing	Total number of accidents	6 320	6 329	6 169	6 315	6 192
	Numbers of serious accidents	3 768	3 652	3 458	3 346	3 289
	Number of workers	319 495	322 521	329 456	334 469	338 680
	Serious accident rates	**11,8**	**11,3**	**10,5**	**10,0**	**9,7**

6.4. Inconsistencies in the Norwegian Statistics

Via emails, SSB confirmed that the statistical data for registered number of employees in *table 07984* (SSB 2019b); and numbers of reported accidents in *table 10914* (SSB 2019d); could be used for calculating industry accident rates (personal communication, October 25, 2019). *Table 10914* is also the one showing the accident rates calculated by SSB. Put into eq. (3) from however, these accident- and employee numbers do *not* generate the same accident rates as those displayed in the *table*. Consequently, neither are the calculated numbers of workers (using the number of reported accidents and accident rates in *table 10914* as input); or the calculated numbers of accidents (using the number of registered workers in *table 07984* and the accident rates in *table 10914*), the same as those displayed in *table 07984* and *10914*, respectively. The inconsistencies are shown in table 8.

Table 8: Inconsistencies in the Norwegian accident statistics. Inconsistencies regarding number of workers; number of serious accidents; serious accident rates per 1 000 workers. Note that the gap between reported number of accidents and calculated number of accidents would be the same as for the other two posts was it defined as gap in percentage from the calculated number. Source: SSB (2019b; 2019d).

		Year				
		2014	2015	2016	2017	2018
Statistics as displayed in SSB's *tables*	Number of workers	212 556	207 487	212 287	219 348	225 672
	Number of serious accidents	1 344	1 425	1 385	1 391	1 369
	Serious accident rates	6,4	6,2	5,8	5,5	5,2
Calculated statistics	Number of workers	210 000	229 839	238 793	252 909	263 269
	Number of serious accidents	1 360	1 286	1 231	1 206	1 173
	Serious accident rates	6,3	6,9	6,5	6,3	6,1
Gap in percentage (from reported)	**Number of workers**	**-1,2**	**10,8**	**12,5**	**15,3**	**16,7**
	Number of serious accidents	**1,2**	**-9,7**	**-11,1**	**-13,3**	**-14,3**
	Serious accident rates	**-1,2**	**10,8**	**12,5**	**15,3**	**16,7**

When asked about the gap between the reported rates and those calculated using data from the aforementioned SSB *tables*; SSB suggested two reasons for the presence of these differences: (1) the statistics used in SSB's calculations deviate from those displayed in the *table 07984*, due to adjustments being made to comply with Eurostat's methodology; or (2) that workers may perhaps sometimes be registered within several industries, and that different registrations are used in the calculations than those that are displayed in the *tables* on their website. The impression from the wording of the communication is that the former explanation is most likely the main reason for the inconsistencies. Even so, SSB did express that, whatever the reason, the magnitude of the diffrences was both unexpected and unfortunate; and that it would be a natural topic for discussion when the statistics are up for revision later this year. (personal communication, October 30, 2019)

6.5. Under-reporting of Accidents

Judging by the statistics presented in figure 2, it seems likely that other countries can improve upon their citizens' occupational safety by mimicking some of the measures taken here in Norway. There is some cause for concern however, as Statens Arbeidsmiljøinstitutt estimates that there may be as much as 100 000 occupational accidents in Norway each year, even though SSB's statistics show that only around 22 500 accidents are being reported annually. Additionally, SSB mentions that many self-employed workers do not have National Insurance registered at NAV, thereby lacking incentives for reporting accidents because they cannot claim economical support in the form of disability benefits. As already mentioned, the construction industry is made up by a lot of small sized enterprises, many of which are self-employed. Therefore, under-reporting may possibly be even more persistent in the construction industry, than it is for all industries combined. (SSB 2017)

Of course, under-reporting is not an issue exclusively present here in Norway, and Kurppa (2015) suggests that decision makers are faced with severely inaccurate accident statistics in many countries. However, if Statens Arbeidsmiljøinstitutt's estimate is correct, around 77,5% of all occupational accidents in Norway go unreported; while in Denmark the estimate is 'just' 45% (AT n.d.). While also this is a high number, it is considerably lower than the 77,5% estimate for under-reporting in Norway. Sweden's AV (2020b) reports a rate more similar rate to the Norwegian one, stating that less than 30% of accidents are expected to be reported; the equivalent of saying that under-reporting is at more than 70%. The numbers are, however, highly uncertain, and they *cannot* be understood as undisputable evidence that the problem of under-reporting is de facto greater in Norway and Sweden, than it is in Denmark. Nevertheless, the numbers *do* indicate that such may actually be the case. Estimated numbers for under-reporting of accidents in the EU have not been found. They are however assumed to be high, but also to vary significantly between member countries (Eurostat 2019). Figure 3 shows the serious accident rates in the construction industry in Norway, Denmark and Sweden, assuming 77,5; 45 and

70% under-reporting, respectively; as well as the reported rates. Fortunately though, the figure most likely presents a situation that is worse than the reality, as the rate of under-reporting is found to be decreasing when the severity of accidents increases (Gravseth, Wergeland and Lund 2003).

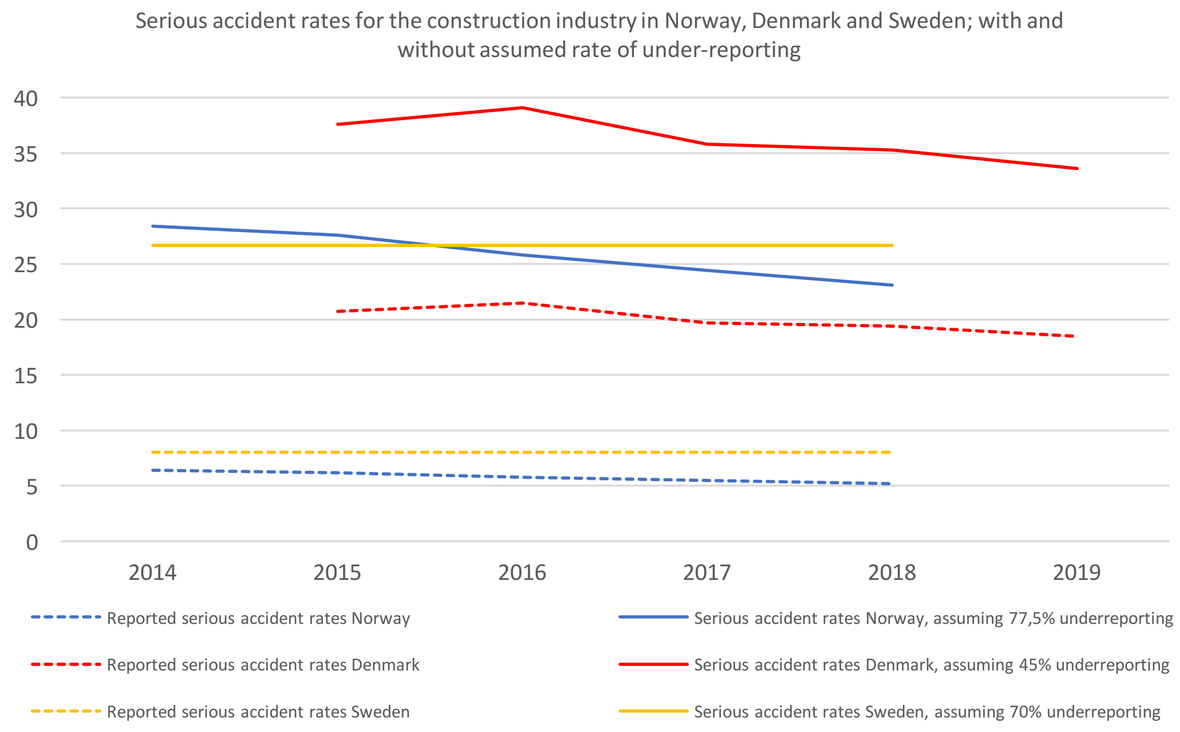

Figure 3: Serious accident rates for the construction industry in Norway, Denmark and Sweden; with and without the respective countries' assumed rates of under-reporting. The rates are shown per 1 000 workers. Source: AT (2020b; 2020d; n.d.); AV (2020a; 2020b); SSB (2017; 2019d) [the statistics for Denmark has been processed as described in section 6.3].

6.6. Estimating the Degree of Under-reporting

There are several ways in which one can estimate the degree of accident under-reporting. Methods include both surveys and assessments of hospital records. A third method is derived from the assumption that fatal accidents less under-reported than non-fatal ones (Heuvel et al. 2017). SSB (2017) claims that there is no reason to believe that fatal accidents are under-reported in Norway, although Arbeidstilsynet (n.d.) in Norway (not to be confused with Denmarks Arbejdstilsynet) expresses concerns that this may not be completely true. Such under-reporting is more however – according to Arbeidstilsynet – more likely to occur within transportation and agriculture, and it does seem like a reasonable presumption that under-reporting is much less widespread, relatively speaking, for fatal injuries than it is for non-fatal ones. Furthermore, it is reasonable to assume that there is some correlation between the real number of fatal- and non-fatal occupational accidents. Research has indeed substantiated such assumptions, and the comparison of reported fatal- and non-fatal accidents is one of the methods used for estimating under-reporting of injuries (Heuvel et al. 2017). Presuming the method holds merit, a high rate of fatal accidents per non-fatal accidents indicates that many accidents go unreported. Kurppa (2015) have also found the ratio to be more stable over time in countries where under-reporting is expected to be low. Table 9 shows the ratio between the number of reported non-fatal accidents and those with a fatal outcome in the Norwegian, Danish and Swedish construction industry from 2015 to 2019 (2015 to 2018 for Norway).

Table 9: Fatal and non-fatal accidents and the ratio between them for the Norwegian construction industry. Number of non-fatal accidents; number of fatal accidents; and the ratio of fatal accidents per 1 000 non-fatal accidents; in the construction industry in Norway, Denmark and Sweden. Source: AT (2020b); AV (2020a); SSB (2019c).

		Year					
		2014	**2015**	**2016**	**2017**	**2018**	**2019**
Number of non-fatal accidents	Norway	2780	2 710	2 704	2 567	2 666	–
	Denmark	–	4 812	5 155	5 176	5 423	5 390
	Sweden	–	3 624	3 726	3 770	3 890	3 815
Number of fatal accidents	Norway	11	6	8	7	4	–
	Denmark	–	5	–	5	–	5
	Sweden	–	5	9	7	12	10
Rate of fatal accidents per 1 000 non-fatal accidents	Norway	**3,957**	**2,214**	**2,959**	**2,727**	**1,500**	–
	Denmark	–	**1,039**	–	**0,966**	–	**0,928**
	Sweden	–	**1,380**	**2,415**	**1,857**	**3,085**	**2,621**

If assuming the ratios in table 9 to be good indicators of the level of under-reporting, Norway does indeed perform worse than the other two Scandinavian countries; with an average rate of fatal accidents per 1 000 non-fatal accidents of 2,671, between 2014 and 2018. Norway is also the country with the largest difference between the lowest and highest ratio, with the highest ratio being 163,7% higher than the lowest one. For Denmark and Sweden between 2015 and 2019, the average rates of fatal accidents per 1 000 non-fatal accidents are 0,978 and 2,272, respectively; and the largest difference between the ratios are 12,0 and 123,6% (excluding the years where no fatal accident statistics is shown for Denmark), respectiveliy. While AT's *tables* (2020a; 2020b) indicate that no fatal accidents occurred in the construction industry in 2016 and 2018, Klausen (2020) states that the Danish construction industry has reported between three and six deaths annually in the last seven years. It remains unknown to the author of this thesis why AT's tables do not provide fatal accident numbers for all the years for which they apply.

6.7. Types of Accidents

On average, most reported injuries in the Norwegian construction industry between 2015 and 2018 were linked to falls (21,9%) (only surpassed in 2015 by accidents of unknown causes), followed by injuries linked to being struck by objects (19,5%), while accidents of unknown causes were the third most common ones (16,1%) (SSB 2019e). The former two of these are well in line with two of the issues highlighted by HSE (n.d.) as requiring extra consideration when planning RMAA work; namely falls from heights and falling objects. As already stated, all fatal accidents mentioned in the interviews were related to falls. The interviewees did not reveal any accidents relating to persons being struck by objects, although mentions were made of barriers being put up to avoid such injuries. The most surprising difference between the accident statistics and the interview revelations is perhaps that injuries from electric shocks were mentioned on several occasions in the interviews, while in the accident statistics such injuries accounted for only 6% of construction accidents reported between 2015 and 2018. Table 10 shows the types of occupational accidents being reported in the construction industry in Norway, and their relative occurrence to all reported accidents.

Table 10: Types of reported accidents by type of accident in the Norwegian construction industry. The statistics are shown as; number of accidents; percentage of all accidents; and average percentage of accidents, between 2015 and 2018. Source: SSB (2019e).

	Reported accidents per year				Percentage of all accidents per year				Average percentage (2015-2018)
Type of accident	**2015**	**2016**	**2017**	**2018**	**2015**	**2016**	**2017**	**2018**	
Type of accident unknown	632	377	333	381	23,3	13,9	12,9	14,3	**16,1**
Struck by object	477	552	519	531	17,6	20,4	20,2	19,9	**19,5**
Collision	49	70	69	68	1,8	2,6	2,7	2,5	**2,4**
Overturn	47	44	54	52	1,7	1,6	2,1	1,9	**1,8**
Trapped, crushed	162	149	160	157	6,0	5,5	6,2	5,9	**5,9**
Fall	516	633	596	589	19,0	23,3	23,2	22,1	**21,9**
Cut by sharp or pointed object	346	373	333	370	12,7	13,8	12,9	13,9	**13,3**
Electrical voltage	135	164	161	176	5,0	6,0	6,3	6,6	**6,0**
High/low temperature	10	10	15	18	0,4	0,4	0,6	0,7	**0,5**
Chemicals	33	19	29	26	1,2	0,7	1,1	1,0	**1,0**
Explosion, fire	19	13	8	16	0,7	0,5	0,3	0,6	**0,5**
Aggression, violent threats	4	16	11	17	0,1	0,6	0,4	0,6	**0,4**
Physical violence	2	4	5	5	0,1	0,1	0,2	0,2	**0,1**
Other	284	288	281	264	10,5	10,6	10,9	9,9	**10,5**

6.8. Lack of statistics specifically addressing RMAA work

Even though SSB offers statistics for several types of accidents, each of them can occur during both RMAA- and production work; and although some accidents are probably more likely to occur in one sector than in the other, using the available statistics to determine for which phase accidents occur more frequently is, at best, highly inaccurate. Mail correspondences with SSB in Norway (personal communication, March 5, 2020) and the Labour Department of Hong Kong (personal communication, April 17, 2020) confirmed that neither of them collect separate accident statistics for RMAA workers and production workers within the construction industry. HSE did not respond to such a request. However, the ONS (personal communication, March 9, 2020) confirmed HSE to be the correct addressee for the request, but that they were unlikely to collect separate accident statistics for RMAA work and production work; neither were such statistical data found when searching through HSE's database. As such, directly comparing the safety performance of the two sectors is not possible using these databases.

6.9. How SSB collects and reviews the accident statistics

All businesses registered in the Norwegian Enhetsregisteret are assigned with an organisation number (Brønnøysundregistrene 2019; 2020). The organisation numbers are then ascribed to an industry class in SSB's registers, and the accidents are sorted by industry based on the organisation number of the company of which the injured is employed. Figure 4 shows the proceeding steps of how SSB collects, reviews and publishes its statistics.

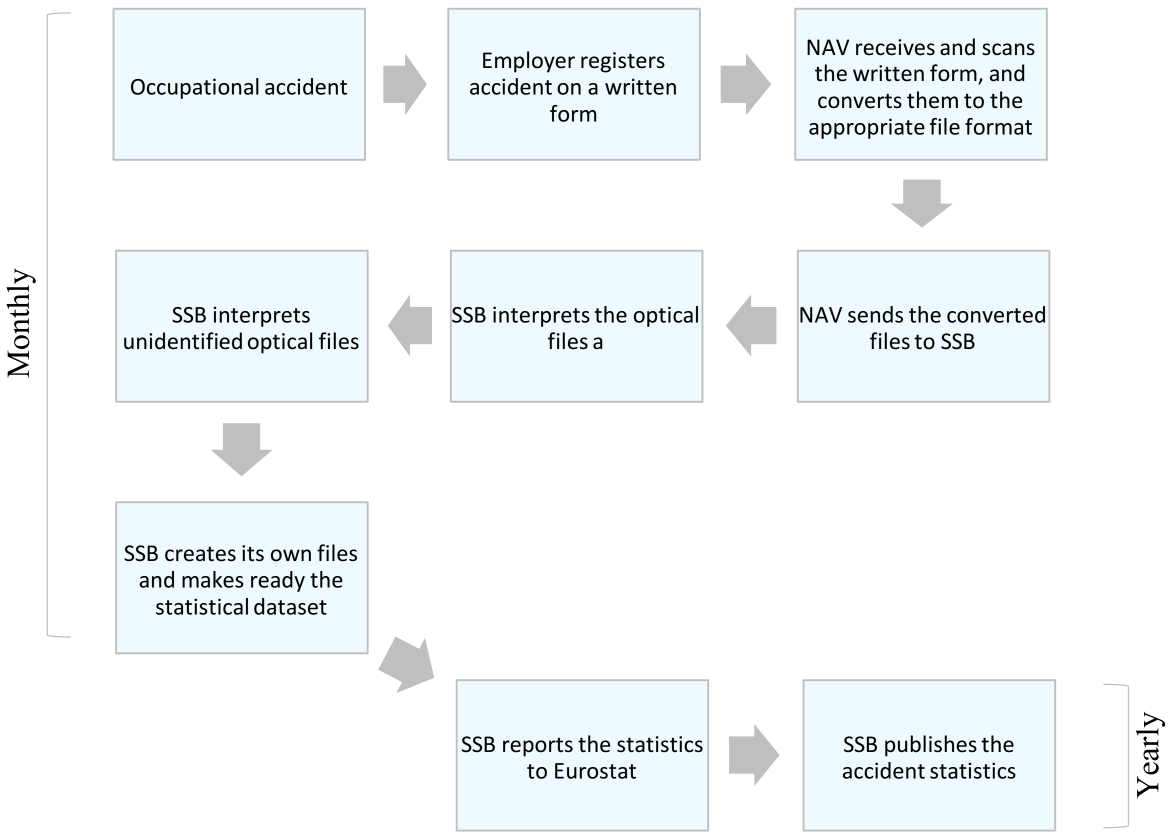

Figure 4:SSB's process of collecting, reviewing and publishing statistics. Source: Personal communication (March 5, 2020)

6.10. Economic Statistics

Investors, project owners, political decision makers and scientists are all influenced by economic interests when prioritizing how and where to spend their resources. Economic assessments of the RMAA sector relative to the whole construction industry, are important (although not adequate on their own) for evaluating whether enough resources are being spent on safety measures and -research in the sector. The RMAA sector is much more important, economically speaking, than it is visible. When initiating new construction projects, project owners tend to focus mostly on the costs of acquisition, somewhat neglecting the future costs of operating the building (Hon, Chan and Yam 2014; Chan and Hon 2016). However, a building's LCC can be multiple times higher than those of acquisition and construction itself (Bogenstätter 2000; Ellis 2007), and a big portion of these costs stem from RMAA activities. Bogenstätter (2000) states that programming and building specifications in a project's early design phases can determine up to 80% of a building's operational costs. Overlooking these aspects when initiating construction projects can thus be a costly mistake.

In Norway, it has been estimated that MOM costs make up approximately 25, 30, 35, 40, and 50% of the LCC of residential buildings, industry buildings, offices, schools and hospitals, respectively. The estimates do not include refurbishment costs as – for several of the building categories – too little data exist regarding how much money is invested in refurbishment activities to make accurate estimates. However, estimates do exist for office buildings, where it is suggested that refurbishment activities account for around 16% of the combined costs of MOM- and refurbishment over the course of a building's lifetime. Of these costs, planned maintenance and operations are estimated at 9 and 14%, respectively. The remaining costs in these estimates cannot directly be ascribed to the construction industry. These costs are related to cleaning (33%), energy consumption (19%), daily operations (9%), security services (6%) and waste management (3%). (Bjørberg, Larsen and Øiseth 2007)

Unfortunately – as is the case with the accident statistics – many statistical databases lack sufficient categorization of different sectors within the construction industry, for the data to be used for assessing the relative economic importance of RMAA works; including SSB's. Fortunately however, the UK's ONS does categorizes its data in a way that makes such assessments possible. Data for costs ascribed to new work; repair and maintenance work; and all work within GB's (not the UK's) construction industry are available through downloadable excel sheets (ONS 2020). Table 11 shows these statistics, as well as the relative increase from last year for each category. The costs of new work and repair and maintenance work, relative to all construction work is also included in the table.

Table 11: Monetary output in GB's construction industry. The output is displayed in billion GBP, as well as in relative output compared to last year for; new work; repair & maintenance work; and all work; also shown is new work and repair & maintenance work relative to all work in in GB's construction industry for each year between 1997 and 2019. Source: ONS (2020) [table 7 in downloadable excel sheet].

	New work		Repair & maintenance work		All work			
Year	**Cost [billion GBP]**	**Increase from last year [%]**	**Cost [billion GBP]**	**Increase from last year [%]**	**Cost [billion GBP]**	**Increase from last year [%]**	**New work/ all work [%]**	**Repair & maintenance work/all work [%]**
1997	36,8	–	24,2	–	61,0	–	60,3	39,7
1998	39,7	8,0	25,1	3,7	64,8	6,3	61,3	38,7
1999	43,2	8,7	25,4	1,2	68,6	5,8	62,9	37,1
2000	45,7	5,8	27,0	6,3	72,7	6,0	62,8	37,2
2001	48,6	6,3	29,4	8,7	78,0	7,2	62,3	37,7
2002	55,0	13,1	32,3	9,8	87,2	11,9	63,0	37,0
2003	61,0	11,0	36,3	12,4	97,3	11,5	62,7	37,3
2004	68,8	12,8	37,9	4,4	106,7	9,7	64,5	35,5
2005	71,5	3,9	40,0	5,6	111,5	4,5	64,1	35,9
2006	77,3	8,1	41,0	2,7	118,3	6,1	65,3	34,7
2007	83,5	8,0	43,6	6,2	127,1	7,4	65,7	34,3
2008	81,7	-2,1	47,0	7,7	128,6	1,2	63,5	36,5
2009	67,6	-17,2	43,5	-7,4	111,1	-13,7	60,8	39,2
2010	74,9	10,8	42,5	-2,3	117,4	5,7	63,8	36,2
2011	77,0	2,8	43,8	3,1	120,8	2,9	63,8	36,2
2012	70,9	-7,9	44,4	1,5	115,4	-4,5	61,5	38,5
2013	74,5	5,0	46,6	4,9	121,1	5,0	61,5	38,5
2014	85,4	14,6	50,4	8,1	135,8	12,1	62,9	37,1
2015	92,0	7,8	50,3	-0,2	142,3	4,8	64,7	35,3
2016	99,8	8,5	51,7	2,7	151,5	6,4	65,9	34,1
2017	109,7	9,9	54,7	5,8	164,3	8,5	66,7	33,3
2018	113,1	3,1	56,0	2,5	169,1	2,9	66,9	33,1
2019	120,8	6,8	57,3	2,3	178,1	5,3	67,8	32,2

The DIW (2011) in Germany offers such statistics as well; and between 2001 and 2010, the German RMAA sector actually accounted for a larger portion of the total construction output, than production work did. Statistics for more recent years have not been found. The CO_2 Building Rehabilitation Programme is likely the main reason that the German RMAA sector constitutes such a large portion of the country's construction industry. Table 12 shows the same statistics for Germany as those displayed for GB in table 11.

Table 12: Monetary output in Germany's construction industry. The output is displayed in billion EUR, as well as in relative output compared to last year for; new work; repair & maintenance work; and all work; also shown is new work and repair & maintenance work relative to all work in in Germany's construction industry for each year between 2001 and 2010. Source: DIW (2011).

	New work		Repair & maintenance work		All work			
Year	**Cost [billion EUR]**	**Increase from last year [%]**	**Cost [billion EUR]**	**Increase from last year [%]**	**Cost [billion EUR]**	**Increase from last year [%]**	**New work/ all work [%]**	**Repair & maintenance work/all work [%]**
2001	52,7	–	91,9	–	144,6	–	36,5	63,5
2002	49,3	-6,5	86,8	-5,6	136,1	-5,9	36,2	63,8
2003	49,5	0,5	83,8	-3,4	133,3	-2,0	37,2	62,8
2004	50,8	2,5	81,9	-2,3	132,7	-0,5	38,3	61,7
2005	44,3	-12,9	82,9	1,3	127,2	-4,1	34,8	65,2
2006	45,8	3,4	90,3	8,9	136,1	7,0	33,6	66,4
2007	37,0	-19,1	106,3	17,7	143,3	5,3	25,8	74,2
2008	32,2	-13,2	115,6	8,8	147,8	3,1	21,8	78,2
2009	31,4	-2,4	116,4	0,6	147,8	-0,0	21,2	78,8
2010	34,1	8,8	122,2	5,0	156,3	5,8	21,8	78,2

7. Legal Sources Regulating Safety at Work

Strict Norwegian laws were highlighted by all interviewees as one of the main reasons for the country's relatively good EHS situation, and they also reported having experienced drastic improvements in this regard during the last 10 to 20 years. Not surprising perhaps, considering the Act of arbeidsmiljøloven (2005) was made enforceable by law in January 2006. A review of the Act is presented in this chapter.

7.1. Lovdata – a Database of Legal Documents

Somewhat simplified, the law consists of Acts and regulations. The Acts and regulations governing EHS in work environments are important sources of information when researching occupational safety. For this purpose, no other database offers the same number of legal sources with the ease of use that Lovdata's website does. Lovdata is a foundation that was established in 1981 by the Norwegian Justice Department and the Faculty of Law in Oslo. Its purpose is to 'establish and operate legal information systems on a non-profit basis' (Lovdata 2020a). The foundation's website contains the primary sources of law that regulates Norwegian citizen's rights and obligations, including; Acts, national- and local regulations, Supreme Court- and Appeals Court decisions, and decisions made by the European Court of Human Rights. A lot of the information is available for free, but through subscriptions, law professionals have access to an even more comprehensive database of legal documents called, Lovdata Pro. Lovdata's database is continuously updated, and the professional version is allowed as a source for official announcements. The foundation is also responsible for supplying the texts for the printed version of Norges Lover. (Lovdata 2020b)

Some of the Acts and regulations that constitutes the laws of Norway have been translated into English by ministries and other public authorities, and are available on Lovdata's website (Lovdata 2020a). Tables 13 to 17 use these translations where they are available and in consistency with the Norwegian version of the law. Lovdata (2020a) explicitly specifies however, that 'the translations are not official; they are provided for information purposes only. In the event of any inconsistency, the Norwegian version shall prevail'. The English texts were compared to the Norwegian ones, and where inconsistencies were found, or where no English version exists, the author of this thesis has translated the Norwegian texts into English. As not all Acts and regulations exist as English versions, English titles are not available for all of them either. As the English versions are not official, and translating the titles oneself seems unnatural, the Acts and regulations are presented by their official Norwegian titles in this thesis. Acts and regulations are referred to in accordance with NTNU's (n.d.) and Språkrådet's (2020) guidelines on the subject.

7.2. Arbeidsmiljøloven

When it comes to occupational safety, no single Act is more important than *arbeidsmiljøloven* (aml). Tables 13 to 17 contain the sections of arbeidsmiljøloven that are perceived as the most important ones for regulating the physical safety of workers in their work environment. Even before taking into account the regulations in which arbeidsmiljøloven grants judicial powers, the Act leaves little leeway for unsafe business practice and -behaviour. Most of the Act's chapters give the Ministry authority to provide regulations that govern EHS matters at an even more detailed level than arbeidsmiljøloven itself. Some such regulations include e.g. *forskrift om utførelse av arbeid* (2011), and *internkontrollforskriften* (1996). These are however not reviewed in detail however, because doing so would require an unreasonable amount of work hours with respect to the research questions of this thesis. Presenting such reviews would also require a disproportionately large number of written pages, relative to the rest of the research presented in the thesis. Tables 13 to 17 comprise the sections of arbeidsmiljøloven that have been considered as the most relevant ones for why governing occupational safety.

Table 13: Purpose and scope of arbeidsmiljøloven. Sections describing the purpose and scope of arbeidsmiljøloven that are relevant to any RMAA undertaking. Source: Working Environment Act (2005).

Purpose and Scope of Arbeidsmiljøloven	
§ 1-1	The purpose of the Act is: a) to secure a working environment that provides a basis for healthy and meaningful working situation, that affords full safety from harmful physical and mental influences and that has a standard of welfare at all times consistent with the level of technological and social development of society, b) to ensure sound conditions of employment and equality of treatment at work, c) to facilitate adaptations of the individual employee's working situation in relation to his or her capabilities and circumstances of life, d) to provide a basis whereby the employer and the employees of undertakings may themselves safeguard and develop their working environment in cooperation with the employers' and employees' organisations and with the requisite guidance and supervision of the public authorities, e) to foster inclusive working conditions.
§ 1-2	(1) The Act shall apply to undertakings that engage employees unless otherwise explicitly provided by the Act.
§ 1-4	(3) The Ministry may provide regulations that the provisions of the Act shall wholly or partly apply to anyone legally responsible for building assignments or his representative.
§ 1-5	(1) The Ministry may issue regulations concerning work performed at the home of the employee and the extent to which the Act shall apply to such work.

Table 14: Responsibilities of the employer. Important sections from arbeidsmiljøloven regarding employers' responsibilities for maintaining safe operations in any RMAA related undertaking. Source: Working Environment Act (2005); arbeidsmiljøloven (2005).

Responsibilities of the Employer	
*	*The section in the English version of the Act deviates from the Norwegian one. The section has been translated from the Norwegian Act by the author of this thesis.*
§ 2-1	The employer shall ensure that the provisions laid down in and pursuant to this Act are complied with.
§ 2-2	(1) When persons other than the employer's own employees, including workers hired from temporary-work agencies or other companies and one-man enterprises, perform tasks in connection with the employer's activities or installations, the employer shall: e) ensure that his own activities and those of his own employees' are arranged and performed in such a manner that persons other than his own employees are also ensured a thoroughly sound working environment, f) cooperate with other employers in order to ensure a thoroughly sound working environment, g) ensure that the working hours of workers hired form temporary-work agencies or other companies comply with the provisions of chapter 10. (2) The principal undertaking shall be responsible for coordinating the health, environment and safety work of each undertaking. If more than 10 employees are employed at the same time and none of the undertakings may be regarded as the principal undertaking, it shall be agreed in writing which undertaking shall be responsible for coordination. In the event that no such agreement is reached, the Labour Inspection Authority [Arbeidstilsynet] shall be notified and shall decide which employer shall be responsible for the coordination.
§ 2 A-3	(1)* When having been notified of censurable conditions at the undertaking, the employer shall see to that the contents of the notification is sufficiently investigated. (2)* The employer shall particularly see to that the notifying employee have a thoroughly sound working environment. If necessary, the employer shall make sure that measures are being taken to prevent retaliation against the notifying employee.
§ 3-1	(1) In order to safeguard the employees' health, environment and safety the employer shall ensure that systematic health, environment and safety work is performed at all levels of the undertaking. This shall be carried out in cooperation with the employees and their elected representatives. (2) Systematic health, environment and safety work entails that the employer shall: a) establish goals for health, environment and safety, b) have an overall view of the undertaking's organisation, including how responsibility, tasks and authority for work on health, environment and safety is distributed, c) make a survey of hazards and problems and, on this basis, assess risk factors in the undertaking, prepare plans and implement measures in order to reduce the risks, d) during planning and implementation of charges in the undertaking, assess whether the working environment will be in compliance with the requirements of this Act, and implement the necessary measures, e) implement routines in order to detect, rectify and prevent contraventions of requirements laid down in or pursuant to this Act, f) ensure systematic prevention and follow-up of absence due to sickness, g) ensure continuous control of the working environment and the employees' health when necessitated by risk factors in the undertaking, cf. (c), h) conduct systematic supervision and review of the systematic work on health, environment and safety in order to ensure that it functions as intended. (3) The ministry may by regulation issue further provisions concerning implementation of the requirements of this section, including requirements regarding documentation of the systematic health, environment and safety work.
§ 3-2	(1) In order to maintain safety at the workplace, the employer shall ensure: a) that employees are informed of accident risks and health hazards that may be connected with the work, and that they receive the necessary training, practice and instruction, b) that employees charged with directing or supervising other employees have the necessary competence to ensure that the work is performed in a proper manner with regards to health and safety, c) expert assistance, when this is necessary in order to implement the requirements of this Act.

	(2) When satisfactory precautions to protect life and health cannot be achieved by other means, the employer shall ensure that satisfactory personal protective equipment is made available to the employees, that the employees are trained in the use of such equipment and that the equipment is used. (3) If work is to be carried out that may involve particular hazards to life or health, written instructions shall be prepared prescribing how the work is to be done and what safety measures are to be implemented. (4) The Ministry may issue regulations concerning implementation of the provisions of this section. The Ministry may also by regulation lay down further provisions concerning personal protective equipment, including provisions concerning: a) design, labelling, etc. b) use, maintenance, etc. c) testing, certification and approval d) approval of bodies set up to exercise supervision in relation to production of personal protective equipment. The ministry may by regulation provide that the provisions concerning personal protective equipment shall also apply to the manufacturer, importer and supplier.
§ 3-3	(1) The employer is obliged to provide occupational health services approved by the Labour Inspection Authority for the undertaking when so necessitated by risk factors in the undertaking. The assessment of whether such an obligation exists shall be made as part of the implementation of the systematic health, environment and safety measures. (2) The occupational health service shall assist the employer, the employees, the working environment committee and safety representatives in creating safe and sound working conditions. (3) The occupational health service shall have a free and independent position as regards working environment matters. (4) The Ministry may by regulation issue further provisions prescribing when and to what extent the employer is obliged to provide occupational health services, the professional requirements regarding such services and the tasks it shall perform.
§ 3-5	(1) The employer shall undergo training in health, environment and safety work.
§ 5-1	(1) The employer shall ensure that all personal injuries occurring during the performance of work are recorded. The same shall apply to diseases assumed to have been caused by the work or conditions at the workplace. (2) The records must not contain medical information of a personal nature without the consent of the person to whom the information applies. The employer shall treat as confidential information in the records concerning personal matters. (3) The records shall be accessible to the Labour Inspection Authority, safety representatives, occupational health services and the working environment committee.
§ 5-2	(1) If an employee dies or is seriously injured as the result of an occupational accident, the employer shall immediately and by the quickest possible means notify the Labour Inspection Authority and the nearest police authority. The employer shall confirm the notification in writing. The safety representative shall receive a copy of the confirmation. (3) The Ministry may provide in regulations that the employer shall notify the Labour Inspection Authority of: a) occupational accident in respect of which notification is not required pursuant to the first or second paragraph, including acute poisonings, and any near accidents, b) any disease that is, or may be, caused by the work or by conditions at the workplace.
§ 8-1	(1) In undertakings that regularly employ at least 50 employees, the employer shall provide information concerning issues of importance for the employees' working conditions and discuss such issues with the employees' elected representatives.
§ 9-4	(1) The employer may only require medical examinations to be conducted: b) in connection with posts involving particularly high risks, c) when the employer finds it necessary in order to protect life or health.

Table 15: Responsibilities of the employee. Important sections from arbeidsmiljøloven regarding employees' responsibilities for maintaining safe operations in any RMAA related undertaking. Source: Working Environment Act (2005).

Responsibilities of the Employee	
§ 2-3	(1) Employees shall cooperate on the design, implementation and follow-up of the undertaking's systematic work on health, environment and safety. Employees shall take part in the organised safety and environmental work of the undertaking and shall actively cooperate on implementation of measures to create a satisfactory and safe working environment. (2) Employees shall: a) use the prescribed protective equipment, exercise caution and otherwise contribute to prevention of accidents and injury to health, b) immediately notify the employer and the safety representative and to the extent necessary other employees when unable to remedy the fault or defect, c) interrupt work of the employees consider that it cannot continue without involving danger to life or health, d) ensure that the employer or safety representative is notified as soon as employees become aware of harassment or discrimination at the workplace, e) notify the employer if an employee suffers injury at work or contracts diseases which the employee believes to result from the work or conditions at the working premises, f) cooperate on preparation and implementation of follow-up plans in connection with total or partial absence from work owing to accidents, sickness, fatigue or the like, g) take part in a dialogue meeting when summoned by the employer, cf. section 4-6, fourth paragraph, h) obey other instructions issued by the Labour Inspection Authority. (3) Employees charged with directing or supervising other employees shall ensure that safety and health are taken into consideration when work that comes under their areas of responsibility is being planned and carried out.

Table 16: Responsibilities of the safety representative. Important sections from arbeidsmiljøloven regarding safety representatives' responsibilities for maintaining safe operations in any RMAA related undertaking. Source: Working Environment Act (2005).

Responsibilities of the Safety Representative	
§ 6-1	(1) Safety representatives shall be elected at all undertakings subject to this Act. At undertakings with less than 10 employees, the parties may agree in writing upon a different arrangement, which may involve agreeing that the undertaking shall not have a safety representative. Unless otherwise provided regarding the period of validity of the agreement, it shall be considered to apply for two years from the date of signature. The Directorate of Labour Inspection may, following a concrete assessment of the circumstances at the undertaking, decide that it shall nevertheless have a safety representative. At undertakings with more than 10 employees, two or more safety representatives may be elected. (2) The number of safety representatives shall be decided according to the size of the undertaking, the nature of the work and working conditions in general. If the undertaking consists of several separate departments or if employees work shifts, at least one safety representative shall generally be elected for each department or shift team. Each safety area shall be clearly delimited and shall not be larger than that the safety representative can have full control and attend to his duties in a proper manner. (3) Undertakings with more than one safety representative shall have at least one senior safety representative, who shall be responsible for coordinating the activities of the safety representatives. The senior safety representative shall be elected from among the safety representatives or other persons who hold or have held positions of trust at the undertaking. (4) Notices giving the names of those acting as safety representatives at any given time shall be posted at the workplace.
§ 6-2	(1) The safety representative shall safeguard the interests of employees in matters relating to the working environment. The safety representative shall ensure that the undertaking is arranged and maintained, and that the work is performed in such a manner that the safety, health and welfare of the employees are safeguarded in accordance with the provisions of this Act.

	(2) The safety representative shall particularly ensure: a) that employees are not exposed to hazards from machines, technical installations, chemical substances and work processes, b) that safety devices and personal protective equipment are provided in adequate numbers, that they are readily accessible and in proper condition, c) that the employees receive the necessary instruction, practice and training, d) that work is otherwise arranged in such a way that the employees can perform the work in a proper manner with regard to health and safety, e) that notifications concerning occupational accidents, etc. are made, pursuant to section 5-2. (3) As soon as a safety representative learns of circumstances that may result in accidents and health hazards, the safety representative shall immediately notify the employees at the location, and if the safety representative is unable to avert the danger himself, he shall bring the matter to the attention of the employer or the employer's representative. When so notified, the employer shall give the safety representative a reply. If no action has been taken within a reasonable space of time, the safety representative shall notify the Labour Inspection Authority or the working environment committee. (4) The safety representative shall be consulted during the planning and implementation of measures of significance for the working environment within the representative's safety area, including establishment, exercise and maintenance of the undertaking's systematic health, environment and safety work, cf. section 3-1. (5) The safety representative shall be informed of all occupational diseases, occupational accidents and near accidents in his or her area, of reports and measurements relating to occupational health and of any faults or defects detected. (6) The safety representative shall familiarise himself with current safety rules, instructions, orders and recommendations issued by the Labour Inspection Authority or the employer. (7) The safety representative shall participate in inspections of the undertaking by the Labour Inspection Authority.
§ 6-3	(1) If a safety representative considers that the life or health of employees is in immediate danger and such danger cannot be averted by other means, work may be halted until the Labour Inspection Authority has decided whether work may be continued. Work may only be halted to the extent the safety representative considers necessary in order to avert danger. (2) The halting of work and the reason for this shall be reported without delay to the employer or the employer's representative. (3) The safety representative is not liable for any loss suffered by the undertaking as a result of work being halted pursuant to the provision laid down in the first paragraph.

Table 17: Requirements regarding the working environment and the working conditions. General requirements for maintaining a sound working environment and good working conditions in any RMAA related undertaking. Source: Working Environment Act (2005); arbeidsmiljøloven (2005).

Requirements Regarding the Working Environment and the Working Coonditions	
Note: Chapter 4 of aml. addresses requirements to the working environment. Arguably, most of these sections can be placed under the responsibilities of the employer. However, the wording of most of its sections can be interpreted as that these responsibilities to be shared by everyone within an organisation or undertaking. Therefore, most of the relevant sections from this chapter are placed in this table. * *The section in the English version of the Act deviates from the Norwegian one. The section has been translated from the Norwegian Act by the author of this thesis.* ** *Section is not numbered correctly in the English version and its content is slightly different from the Norwegian version. The author has made some slight changes for the section to comply with the Norwegian version.*	
§ 2 A-1	(1) An employee has a right to notify censurable conditions at the employer's undertaking. Workers hired from temporary-work agencies also have a right to notify censurable conditions at the hirer's undertaking.

	(2)* Censurable conditions are conditions which contradicts the law, the undertaking's written ethical guidelines or ethical norms which are conventionally supported by society at large, e.g. conditions which involve, or impose: a) danger to life or health, e) unhealthy or dangerous working environment.
§ 2 A-4	(1)** Retaliation against an employee who notifies pursuant to section 2 A-1 and section 2 A-2, is prohibited.
§ 4-1	(1) The working environment in the undertaking shall be fully satisfactory when the factors in the working environment that may influence the employees' physical and mental health and welfare are judged separately and collectively. The standard of safety, health and working environment shall be continuously developed and improved in accordance with developments in society. (2) When planning and arranging the work, emphasis shall be placed on preventing injuries and diseases. The organisation, arrangement and management of work, working hours, pay systems, including use of performance-related pay, technology, etc., shall be arranged in such a way that the employees are not exposed to adverse physical or mental strain and that due regard is paid to safety considerations. (3) It shall be assessed whether there are any special risks associated with working alone in the undertaking. Measures necessary for preventing and reducing any risk of working alone shall be implemented in order to meet the statutory requirements regarding a fully satisfactory working environment. (7) The Ministry may issue regulations requiring the use of HSE cards by employees in branches where this is necessary or appropriate in order to safeguard the employees' health, environment and safety and concerning lists of persons at any time employed at the workplace. If so ordered by the Ministry, public authorities shall be obliged notwithstanding the duty of secrecy to provide the issuer of HSE cards with all information from public registers that is necessary for the issue of HSE cards. (8) When consideration for health, environment and safety so indicates, the Ministry may issue regulations providing that undertakings operating cleaning services must be approved by the Labour Inspection Authority and concerning the detailed contents of such an approval arrangement. When such approval is required, it will be unlawful to utilise services operated by undertakings with no such approval.
§ 4-2	(1) The employees and their elected representatives shall be kept continuously informed of systems used in planning and performing the work. They shall be given the training necessary to enable them to familiarise themselves with these systems, and they shall take part in designing them. (3) During reorganisation processes that involve changes of significance for the employees' working situation, the employer shall ensure the necessary information, participation and competence development to meet the requirements of this Act regarding a fully satisfactory working environment.
§ 4-4	(1) Physical working environment factors such as factors relating to buildings and equipment, indoor climate, lighting, noise, radiation and the like shall be fully satisfactory with regard to the employees' health, environment, safety and welfare. (2) The workplace shall be equipped and arranged in such a way as to avoid adverse physical strain on the employees. Necessary aids shall be made available to the employees. Arrangements shall be made for variation in the work and to avoid heavy lifting and monotonous repetitive work. When machines and other work equipment are being installed and used, care shall be taken to ensure that employees are not subjected to undesirable strain as a result of vibration, uncomfortable working positions and the like. (3) Machines and other work equipment shall be designed and provided with safety devices so that employees are protected against injuries. (4) Living quarters made available to employees by the employer shall be properly constructed, equipped and maintained. Any house rules shall be drawn up in consultation with employees' representatives.
§ 4-5	(1) When handling chemicals or biological substances, the working environment shall be so arranged that employees are protected against accidents, injuries to health and excessive discomfort. Chemicals and biological substances shall be manufactured, packed, used and stored in such a way that employees are not subjected to health hazards. (2) Chemicals and biological substances that may involve health hazards shall not be used if they can be replaced by other substances or by another process that is less hazardous for the employees.

	(3) The undertaking shall have the necessary routines and equipment to prevent or counteract injuries to health due to chemicals or biological substances.
§ 7-1	(1) Undertakings which regularly employ at least 50 employees shall have a working environment committee on which the employer, the employees and the occupational health service are represented. Working environment committees shall also be formed in undertakings with between 20 and 50 employees when so required by any of the parties at the undertaking. Where working conditions so indicate, the Labour Inspection Authority may decide that undertakings with less than 50 employees shall establish a working environment committee.
§ 7-2	(1) The working environment committee shall make efforts to establish a fully satisfactory working environment in the undertaking. The committee shall participate in planning safety and environmental work and shall follow up developments closely in questions relating to the safety, health and welfare of the employees. (2) The working environment committee shall consider: a) questions relating to the occupational health service and the internal safety service, b) questions relating to training, instruction and information activities in the undertaking that are of significance for the working environment, d) other plans that may be of material significance for the working environment, such as plans for construction work, purchase of machines, rationalisation, work processes, and preventive safety measures, e) establishment and maintenance of the undertaking's systematic health, environment and safety work, cf. section 3-1, f) health and welfare issues related to working-hour arrangements. (4) The committee shall study all reports relating to occupational diseases, occupational accidents and near accidents, seek to find the cause of the accident or disease and ensure that the employer takes steps to prevent recurrence. As a general rule the committee shall have access to Labour Inspection Authority and police inquiry documents. When the committee considers it necessary, it may decide that inquiries shall be conducted by specialists or by a commission of inquiry appointed by the committee. Without undue delay the employer may submit such decisions to the Labour Inspection Authority for decision. The committee shall study all reports relating to occupational health inspections and measurements. Before such reports as mentioned in this paragraph are considered by the committee, medical information of a personal nature shall be removed from the reports, unless the person to whom the information applies consents to it being submitted to the committee. (5) If the working environment committee considers it necessary in order to protect the life or health of employees, it may decide that the employer shall implement concrete measures to improve the working environment within the framework of the provisions laid down in or pursuant to this Act. In order to determine whether a health hazard exists, the committee may decide that the employer shall conduct measurements or examinations of the working environment. The committee shall impose a time limit for implementation of the decision. If the employer finds that he is unable to implement the committee's decision, the matter shall be submitted without undue delay to the Labour Inspection Authority for decision.
§ 10-2	(1) Working hours shall be arranged in such a way that employees are not exposed to adverse physical or mental strain, and that they shall be able to observe safety considerations.
§ 13-1	(1) Direct and indirect discrimination on the basis of political views, membership of a trade union, or age is prohibited. (4) In the case of discrimination on the basis of gender, pregnancy, leave of absence in connection with childbirth or adoption, care responsibilities, ethnicity, religion, belief, disability, sexual orientation, gender identity or gender expression, the Equality and Anti-Discrimination Act (likestillings- og diskrimineringsloven) shall apply.

8. Conclusion

The findings in this thesis do confirm the construction industry to be one of those with the highest number of accidents, both in terms of absolute and relative numbers. The EHS situation in the Norwegian construction industry does seem to be one of the best in the world, but indications exist that the country may be plagued by a higher relative number of unreported accidents than its Scandinavian neighbours (excluding Finland as not comparable data has been found for the country). The existence of under-reporting is generally suggested to be high in most countries, but it is also suggested to be varying greatly between them. Even when adding the assumed number of unreported accidents to the reported ones, Norway compares favourably to Denmark, and almost equal to Sweden, even though the relative estimates of under-reporting is lower in these countries. It should also be noted under-reporting is assumed to be less common for severe accidents than it is for less severe ones. The statistics suggest that the Norwegian construction industry is one of the safest in the world.

The main research questions of the thesis proved very difficult to answer though, as specific accident statistics for RMAA work and production work have not been found. Consequently, the research has *not* been able to confirm that RMAA workers are more susceptible to injuries than those working production, as stated in exercise EUF 3.05 (corresponding to EUF 5.09 in 2020) of TBA4501 – Real Estate and Property Management, Specialization Project (NTNU 2020). While several sources make claims indicating such to be the case (e.g. Hon, Chan and Wong 2010; OSHWiki contributors 2017), no statistical database has been found that explicitly proves them. Where the claims have been cited, the references lead to sources that are no longer available online. It must be noted however, that neither of the sources specifically addressed the Norwegian RMAA sector. Therefore, it remains unknown whether RMAA workers in Norway are more susceptible to injury than production workers.

Some economic statistics for the construction industry, do separate RMAA work and production work. Unfortunately, such data has only been found for GB and Germany. The data from these two countries do however highlight that the RMAA sector is much larger, economically speaking, than it is visible. In Germany, the monetary output of RMAA work was actually higher than that of production work, accounting for between 61,7 and 78,8% of all work in each year between 2001 and 2010 (newer data has not been found). Although such is not the case in GB, RMAA work still accounts for a high portion of all construction work, with a relative monetary output between 32,2 and 39,7% of all work in each year between 1997 and 2019.

Differentiating RMAA work from production work provides useful information regarding where costs are being spent, and it can help those in charge make more qualified decisions when prioritizing resource spending. Such a distinction would also be beneficial when assessing each of the two industry sectors' safety performance, and could help shed light on specific dangers that are present within them; as well as offering direct knowledge of how they perform relative to all construction work. It is therefore the view of this author, that the two sectors should be distinguished in a similar manner to how they are categorized in ONS and DIW's statistics. It is also suggested that the sector distinction should apply when collecting, reviewing and publishing both accident- and economic statistics. Environmental statistics have not been reviewed for this thesis, and it is therefore not known to its author whether or not such categorization is common for these statistics.

As was the case with the first research question, neither has the conducted investigations clearly been able answer the second one by pointing out particular aspects of the RMAA industry with a clear potential for improvement with regard to safety. The interviewees were generally quite happy with the situation today, although they did sometimes experience communication issues leading to dangerous or unwanted situations. When such issues occurred however, their causes did not seem to be easily identified; neither were the issues necessarily similar in nature. One interviewee pointed out that they experienced macho culture to impose some unwanted cases, but the other three did not view macho culture as a particular concern, stating that the situation has improved drastically during the last 10 to 20 years. One interviewee pointed out that there is a potential for improvement regarding the early planning and programming phases of construction projects, having experienced several RMAA related issues on a relatively new construction; but the others seemed fairly satisfied with how planning and programming are performed in newer projects, stating that future maintenance work is considered on all new projects that their companies are involved with. All interviewees mentioned their own EHS frameworks and strict Norwegian laws as some of the main reasons why occupational safety in Norway is as good as it is. The laws and regulations in Norway give little leeway for businesses to take dangerous shortcuts; rather, they provide strong incentives for employers to make sure the business is performed in the safest possible manner.

9. Discussion and Suggestions for Further Research

With all the knowledge that I've gained throughout my research, there are of course things I would have done differently if I were to answer the same research questions again. Some of the changes that I would ideally have liked to make, however, would probably make the work too comprehensive for me – as an inexperienced student researcher – to execute alone. An example is that I would ideally have liked to gather interview data that could be used to either confirm or discard the hypothesis that RMAA work does involve more injuries than production work does; and to do so with statistical significance. For the interviews to generate such information however, they would need to; (1) be conducted with representatives from both the RMAA part- and the production part of the construction industry; (2) be performed on a much larger scale, involving both large and small enterprises, ideally from all over the country; and (3) be conducted with interview subjects presenting several different professions within the two parts of the industry (RMAA and production). I do believe that gathering enough such data to create statistically significant results, would be an impossibly comprehensive undertaking for me alone, at least for a master thesis. Still, if I were to start over, I would probably make the interview guide a bit shorter, and I would have asked more businesses to participate, although it might have proved difficult getting as many respondents as I wanted, as it did take quite some time just to get the four interviews that I did. I am very thankful to those who disposed some of their time to answer my questions. It is my belief that to some (quite a large) extent, this can be blamed on the COVID-19 virus that has been plaguing the world this recent semester; and that without it, more interviews could have been arranged. A lot of companies have been downsizing their workforce – some temporarily, some permanently – and all businesses have been facing a previously uncharted territory of logistical challenges. The rapid outbreak of the virus, and the measures put in place to contain its spread, have been – and, to some extent, continues to be – highly disruptive to most aspects of society; and has taken its toll on students and salaried workers alike. It is therefore very understandable that many undertakings have not been able to prioritize taking part in student research interviews.

Further research could also include; how lead and lag indicators can be used to improve the safety performance of RMAA work; and investigations of whether lean production is utilized in the RMAA sector, and if it benefits workers' safety.

The thesis refers to previous research indicating that RMAA work is more dangerous than production work. As earlier stated, the background data for these claims was not possible to find within the limits for this thesis. This could be investigated further and the relevance for Norwegian conditions assessed.

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STATSBYGG

Instruks for eksterne håndverkere

Formål	Dokumentasjon på HMS
Oppfølgingsansvar	Underdirektør (Drift og vedlikeholdsavdeling)
Utføres av	Bestiller og utførende (kontrahert personell)
Underordnet prosedyren	SHA og HMS ved drifts- og vedlikeholdsarbeider
Henvisninger	Risikovurdering for drift og vedlikeholdsarbeider Sikker jobbanalyse (SJA)

Beskrivelse

Eiendom:	Kontaktperson i Statsbygg:
Utførende firma/person:	Arbeid som skal utføres:

Bruk av verneutstyr:

Arbeider i publikumsområder skal sperres av og innenfor sperringer skal påbudt verneutstyr brukes. Eks: Ved arbeid i himling skal det sperres av rundt tilkomstverktøy (stige, løfteplattform etc.) slik at ulykker unngås. Verneutstyr innenfor sperringer er hjelm (vernecaps), vernebriller og vernesko (som minimum).

Sjekkliste

Nr	GENERELT	OK
1	Jeg vet at jeg skal registrere meg inn og ut på kortleser eller app hver dag (HMSREG). Inn/ut-stempling må gjøres på samme leser innenfor samme dag. Hjelpepersonell skal også registreres.	
2	Det skal daglig meldes til driftstjenesten når arbeidet igangsettes og avsluttes.	
3	Besøks/nøkkelkort skal alltid bæres synlig og innleveres driftstjenesten etter avtale.	
4	Jeg har underskrevet taushetserklæring og levert til kontaktpersonen min.	
5	Jeg skal ikke gå andre steder enn det som er avtalt med min kontaktperson.	
6	Jeg kjenner til reglene for røyking på eiendommen.	
7	Det skal benyttes rent arbeidstøy. Firmanavn skal fremgå.	
8	Spising skal ikke foregå i arbeidsområder eller tilstøtende korridorer, men fortrinnsvis i kantina. I kantinen skal det benyttes rent arbeidstøy.	

Nr	VED ARBEID	OK
9	Ved farlige eller risikofylte arbeider skal det utføres Sikker Jobb Analyse (SJA). Kopi leveres til kontaktperson hos Statsbygg før arbeidet igangsettes.	
10	Ved varme arbeider skal skjema «Instruks for varmt arbeid» fylles ut.	
11	Støyende arbeider som hulltaging, pigging, bruk av vinkelkutter, etc samt varme arbeider skal avtales med driftstjenesten.	
12	Ved støvende arbeider skal arbeidsområdet tildekkes så det ikke forurenser ut i tilstøtende lokaler.	
13	Alle arbeider skal utføres i henhold til «Rent tørt bygg-prinsippet». Det skal kun brukes støvsuger og direkteavsug fra bor- og slipe/sageutstyr.	
14	Jeg kjenner til at alt arbeid skal dokumenteres, dateres og signeres.	
15	Frakopling av strøm og vann skal avtales. Jeg skal sjekke at alt fungerer som det skal når jeg er ferdig.	
16	Jeg skal rydde avfall etter meg hver dag og rengjøre når arbeidet er utført.	
17	Jeg er ansvarlig for at brannmeldere slås av ved behov med hjelp fra Statsbygg.	
18	Lagring av materiell gjøres på avtalte plasser.	

Kommentar til eventuelle manglende kryss:

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...

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...

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...

Instruksen er gjennomgått og oppfylt (utførende): Sign./dato:	Kontaktperson ved Statsbygg: Sign./dato:

STATSBYGG

PROSESS I HUSET
DRIFT OG VEDLIKEHOLD/PLANLEGGE OG UTFØRE
DOKUMENTTYPE
PROSEDYRE

Arbeidsinstruks for drift- og vedlikeholdsarbeider på tak og i høyden

Formål	Denne instruksen er utarbeidet for å unngå skade på liv og helse for arbeidstakere som utfører drift- og vedlikeholdsarbeider på tak og i høyden
Oppfølgingsansvar	Linjeleder er ansvarlig for at instruksen gjøres kjent og følges Alle ansatte i Statsbygg plikter å påpeke avvik
Utføres av	Alle som arbeider på tak og i høyden har selvstendig ansvar for at arbeidsinstruksen følges
Henvisninger	• Skjema for sikker jobbanalyse (SJA) • Informasjon fra arbeidstilsynet om arbeid i høyden • Informasjon fra arbeidstilsynet om risikovurdering med eksempler • SAMBA for ansatte • Forskrift om sikkerhet, helse og arbeidsmiljø på bygge- eller anleggsplasser (byggherreforskriften

OMFANG / VIRKEOMRÅDE
Instruksen gjelder for alle drift- og vedlikeholdsarbeider på tak og i høyden.

VERNEUTSTYR SKAL BRUKES:
Synlighetsklær
Vernesko
Vernebriller
Vernehjelm
Sikkerhetsseler og liner

VERNEUTSTYR BØR BRUKES:
Hørselvern
Hansker
Samband

UTFØRELSE
Før arbeidet starter:

- **S**ikker **J**obb **A**nalyse skal gjennomføres. (Se skjema for **SJA**)
- Det skal vurderes om det er særlig risiko knyttet til arbeider på tak og i høyden.
- Meld fra til kollega/leder/andre om hvor, når og hvor lang varighet arbeidet har

- Merk av på eventuell oversikt for oppgaveutførelse
- Arbeidsgiver ved linjeleder skal sørge for at utførende har riktig kompetanse, opplæring og informasjon
- Arbeidstager plikter å melde ifra om manglende kompetanse, opplæring og informasjon
- Hvis arbeid i høyden ikke kan unngås, bruk allerede sikrede arbeidsplasser.
- Sørg for at arbeid i høyden utføres på en sikker måte, med egnet arbeidsutstyr og fra en egnet overflate.
- Sørg for at arbeidsutstyret blir kontrollert før bruk. Utstyr som ikke er i orden, skal tas ut av bruk

Under utførelse:

- Ta særlige hensyn til spinkle eller skjøre underlag eller dekker.
- Sørg for kollektivt vern mot fallende gjenstander.
- God belysning gjør arbeidet lettere og sikrere.
- En ryddig arbeidsplass øker sikkerheten.
- Vurder rutiner og tiltak for nødevakuering og redningsoperasjoner.
- Husk ansvar for tredjeperson.
- Utfør så mye som mulig av arbeidet på bakken.
- Legg atkomsten så nær arbeidsområdet som mulig.
- Sørg for at arbeidstakerne kan komme seg trygt fra og til arbeidsstedet. Velg trappetårn til atkomst.
- Forsikre deg om at arbeidsutstyret for arbeid i høyden er egnet, har tilstrekkelig stabilitet og styrke, er vedlikeholdt og er kontrollert regelmessig
- Bruk kollektiv fallsikring – som for eksempel rekkverk – fremfor personlig fallsikringsutstyr.
-
- Stige skal i hovedsak brukes til adkomst, og ikke som arbeidsplattform.
- Stige kan brukes når det på bakgrunn av risikovurdering ikke vil være hensiktsmessig å bruke annet og sikrere arbeidsutstyr.
- Stigen skal oppstilles på en slik måte at stabiliteten er sikret under bruk.
- Stigen skal sikres mot utglidning. Så langt det er praktisk mulig skal stigen festes i toppen eller sikres på annen måte.
- Stigen skal brukes slik at arbeidstakerne hele tiden har et sikkert grep og står støtt.
- Stigen må rage minst 1 meter over adkomstnivået. Dette gjør det enklere å gå av og på stigen.
- Når en stige skal brukes som atkomst, skal den alltid sikres i toppen.
-
- Ved skade på person og/eller materiell skal linjeleder kontaktes
- Alvorlige hendelser skal varsles i henhold til Statsbyggs krise- og ulykkesplan, i linjen til nærmeste overordnede. Statsbyggs krisetelefon: 41 41 05 00

Kan ikke instruksen etterleves må oppgaven vurderes utført av eksterne

Dersom arbeidet skal utføres av eksterne, er det deres plikt å ha arbeidsinstrukser, utføre SJA, bruke sertifisert utstyr, sikre at arbeidstakerne har påkrevet opplæring osv.

Statsbygg SKAL følge opp med stikkprøvekontroll.

På arbeidsområdet:

- Planlegg lagringsplassen for arbeidet; området for lagringsplass er en del av arbeidsområdet.
- Arbeidsområdet skal sikres for å unngå skade på personell og utstyr
- Avsperring i risiko område på bakken etableres, jamfør fallende gjenstander

Noen huskepunkter til risikovurdering:

- Er denne arbeidsinstruksen dekkende for å ivareta **SHA** (Sikkerhet, Helse, arbeidsmiljø)?
- Har det skjedd uønskede hendelser ved denne typen aktivitet tidligere?
- Skal du jobbe sammen med noen du ikke kjenner fra før?
- Er arbeidsoperasjonen ny eller ukjent?
- Innebærer jobben særlig fare for liv og helse?
- Har du riktig dokumentert kompetanse og sertifisering?
- Involverer arbeidet bruk av utstyr som du ikke har erfaring med?
- Kan det forekomme endrede forutsetninger, f.eks. værforhold, endret bemanning, endrede tidsmessige forhold, endret rekkefølge, grensesnitt mot andre aktiviteter etc.?

Internkontroll Elektro - Sjekkliste for kontroll av elektroarbeider

Formål	Sikre at Statsbygg overholder krav i forskrift om elektriske lavspenningsanlegg
Oppfølgingsansvar	Eiendomsforvalter
Utføres av	Bestiller / driftsansatt
Henvisninger	Internkontroll Elektro – Veiledning til elektriske anlegg Forskrift om elektriske lavspenningsanlegg

Sjekkliste gjennomgås etter arbeid utført av elektroinstallatør

Nr	Sjekkpunkt	Kontrollert
1	Det er rengjort og ryddet opp etter utført arbeid	
2	Det ikke oppbevares uvedkommende materiell, løse ledninger og redskap, utstyr mv. i apparatrom / sikringsskap	
3	Kursfortegnelse er ajourført og tydelig skrevet	
4	Sikringer og utstyr er tydelig og varig merket i samsvar med kursfortegnelsen	
5	Elektrotegninger er oppdatert og ajourført mht. endringer/nytt utstyr	
6	Nye branntetninger er utført og godt merket	
7	Nye sikringer og deksler er hele	
8	Nytt utstyr er fastmontert	
9	Fastmontert utstyr har fast tilkobling	
10	Nytt utstyr er helt og rengjort	

11	Nytt utstyr utprøves og kontrolleres om funksjoner virker som forutsatt	
12	Nytt varmeutstyr ikke er montert for nær brennbart materiale	
13	Deksler er på plass slik at nye spenningsførende deler og uisolerte ledninger ikke er umiddelbart tilgjengelige	
14	Kabler for nye åpne installasjoner er forsvarlig festet til underlaget og ikke har mekaniske skader	
15	Kabler ikke er avmantlet utenfor deksel/kapsling	
16	Kabelskjøter ikke er foretatt utenfor koblingsbokser	
17	Kapslinger på brytere, stikkontakter, koblingsbokser og øvrige elektrisk materiell er hele	
18	Ledninger/kabler ikke er utsatt for ekstra skade f.eks. ved at de ligger an mot skarpe kanter	
19	Det ikke er foretatt flere ledningskoblinger i sammen plugg	
20	Bevegelige ledninger ikke er innkledd	
21	Ledningsinstallasjoner som ikke er i bruk blir vedlikeholdt eller fjernet	
22	Nye betjeningsbrytere er merket	
23	Opplegg til teknisk utstyr er helt og uten mekaniske skader, og godt festet til underlaget	
24	Samsvarserklæring er overlevert Statsbygg	

STATSBYGG

SIKKERHET, HELSE OG ARBEIDSMILJØ (SHA)

Skjema for sikker jobbanalyse (SJA)

Prosjekt (navn og nr.):			
Ansvarlig for aktivitet:		SJA nr.:	
SJA-ansvarlig:		Dato utført:	

Kort beskrivelse av arbeidsoperasjonen:

Nedbryting av jobben i trinnvise aktiviteter:

Nr.	*Delaktivitet*	*Uønsket hendelse (hva kan gå galt?)*	*Mulig konsekvens (hvor galt kan det gå?)*	*Risikoreduserende tiltak (hva bør gjøres i tillegg til instruksen på s.1)*	*Ansvarlig*

Utvid skjemaet eller benytt baksiden av arket dersom behov for mer plass.

Kan arbeidet utføres med akseptabel risiko (sett kryss):	Ja ☐ Nei ☐

Signaturskjema – deltakere:

Dato:
Utarbeidet av:
Godkjent av:

Appendix E: Intervjuguide – Norsk

Intervjuguide – Norsk

Informasjon til intervjuobjekt: Det bes om at du tar hensyn til din egen og andres identitet, og at du ikke bruker navn eller særlig sensitiv informasjon som kan brukes til å identifisere spesifikke personer. Bruk vendinger som: 'en kollega…' eller 'en jeg kjenner…' istedenfor navn eller andre særlige kjennetrekk.

1. Hvor mange ansatte er det i bedriften du jobber i? Og i din avdeling?

2. Hva er primæraktiviteten til bedriften du arbeider for? (f.eks. entreprenør, konsulent, drift og vedlikehold). Hvis bedriften er delt opp i flere avdelinger, kan du gjerne skrive en liste over disse, og spesifiser hvilken avdeling du jobber i.

3. Omtrent hvor store beløp dreier kontraktene deres seg om? Om beløpet varierer i stor grad kan du gjerne skrive ned typiske beløp for store, gjennomsnittlige og små kontrakter. Hvis du vet hva den årlige omsetningen til din bedrift-, og til din avdeling er, inkluder gjerne dette også.

4. Omtrent hvor lange tidsperspektiv dreier kontraktene deres seg om? Om tidsperspektivet varierer i stor grad kan du gjerne skrive ned noen eksempler på kortvarige og langvarige kontrakter her.

5. Hva er stillingstittelen din?

6. Vil du identifisere deg selv som en del av byggebransjen?

7. I hvor mange år har du hatt den jobben du har nå? Spesifiser også om du har hatt tidligere jobber som er relevant for den jobben du har nå, og hvor lenge du hadde denne/disse jobben(e).

8. Består jobben din i hovedsak å utføre fysiske eller administrative oppgaver? Lag gjerne en liten beskrivelse av, eller en liste over typiske arbeidsoppgaver du utfører.

9. Har bedriften du jobber for klare retningslinjer for hvordan ditt arbeid skal utføres i forhold til å ivareta HMS (helse, miljø, sikkerhet)? Har dere et skriftlig rammeverk som skal følges? Gjennomgår du ofte sikkerhetskurs? Bruker dere noen form for sjekkliste for sikkerhet? Hender det allikevel at du møter farer som disse retningslinjene ikke tar for seg? Vennligst beskriv slike situasjoner hvis du har opplevd noen.

10. Kreves det noen form for sikkerhets-sertifisering for å utføre jobben din? Må denne sertifiseringen fornyes med jevne mellomrom? I så fall, hvor ofte?

11. Vet du om det eksisterer noen slags samarbeids-organisasjon (som f. eks. SfS BA for bygg- og anleggsbransjen) som arbeider for sikrere vilkår for vedlikeholdsarbeidere? Er dere i så fall medlem av noen slik organisasjon?

12. Har du noen gang vært involvert i eller vært vitne til arbeidsulykker? Eller har du kanskje hørt om arbeidsulykker som kolleger har vært involvert i? Fortell i grove trekk hva som hendte.

13. Har du noen gang opplevd eller vært vitne til sviktende utstyr som har forårsaket en farlig situasjon? Eller kanskje du har hørt om slike tilfeller av dine kolleger? Lag gjerne en liste over slike tilfeller om du kjenner til noen, forklar hva som sviktet, og hvilke farer svikten utgjorde i hvert tilfelle.

14. Har du noen gang opplevd eller vært vitne til situasjoner hvor vedlikehold har vært vanskelig eller farlig å utføre på grunn av dårlig design/utforming av gjenstanden som skal vedlikeholdes, eller at gjenstanden var installert på en dårlig måte? (f.eks. dårlig tilgjengelighet til det som skulle vedlikeholdes) Hvis ja, forklar her.

15. Hender det at vedlikeholdsarbeid må utføres i nærheten av bevegelige deler/systemer? (f.eks. tannhjul i maskineri, sterke vannstrømmer etc.) Spesifiser gjerne disse situasjonene, og hvorvidt dette er noe du gjør ofte eller ikke.

16. Hender det at du må fjerne beskyttelsesutstyr for å utføre det nødvendige vedlikeholdsarbeidet? Spørsmålet omfatter både sikkerhetsutstyr som hjelmer, klatreseler etc. og eventuelt beskyttelse på det som skal vedlikeholdes, som f.eks. skjermer over bevegelige deler etc.

17. Angående forrige spørsmål: Er det tilfeller hvor dette kunne vært unngått hvis det som skulle vedlikeholdes var utformet/designet annerledes? Eller om

arkitekter/ingeniører hadde planlagt bygget bedre for vedlikeholdsarbeid? Spesifiser gjerne konkrete eksempler hvis du har noen.

18. Tror du digitalisering av endel systemer kunne bidra til å øke din arbeidssikkerhet? F.eks. ved sensorer som registrerer når vedlikehold må utføres, hva som må gjøres og hvor det må gjøres? Hvis du kommer på situasjoner eller systemer hvor dette ville vært hjelpsomt, skriv dem ned her.

19. Har du noen gang vært involvert i, eller vitne til situasjoner som viste seg å by på større farer enn det det i utgangspunktet så ut som de skulle gjøre? Eller har du kanskje hørt om slike situasjoner fra kolleger? Er dette noe som hender ofte? Spesifiser gjerne konkrete eksempler om du har noen.

20. Har du noen gang vært involvert i, eller vitne til situasjoner hvor machokultur har påvirket HMS negativt? Eller kanskje du har hørt om slike situasjoner fra kolleger? Beskriv gjerne disse situasjonene om du vet om noen.

21. Har du noen gang vært involvert i, eller vitne til situasjoner hvor farer har oppstått på grunn av mangelfull kommunikasjon? Eller kanskje du har hørt om slike tilfeller fra kolleger? Beskriv gjerne slike situasjoner hvis du vet om noen, og om hvorvidt det er typiske kommunikasjonsproblemer som går igjen.

22. Har du noe inntrykk av hvilke underliggende grunner som i hovedsak er årsaken til at ulykker skjer i din type arbeid? F.eks. mangel på erfaring, mangelfull kommunikasjon, mangelfull bevissthet rundt HMS, utrygg oppførsel, dårlig sikkerhetskultur, sviktende utstyr, utstyr med mangelfull/dårlig funksjonalitet eller design etc. Du kan godt nevne årsaker som ikke er nevnt i eksemplene, og du kan også nevne flere enn én årsak.

23. Har du opplevd endringer hva gjelder fokuset på HMS i løpet av din arbeidskarriere? Beskriv i så fall disse endringene, og spesifiser om endringene har hatt negativ eller positiv innvirkning. Skriv gjerne ned alt du kan komme på. Det kan både dreie seg om tekniske eller kulturelle endringer.

Appendix F: Interview guide – English

Interview guide – English

Information to the interviewee: It is asked that you respect your own and others' identity, and that you avoid using names or other sensitive information that can be used to directly identify specific persons. Use language like: 'a colleague of mine…' or 'someone I know…' instead of names or other specific characteristics.

1. How many employees are employed in the company you work for?

2. What is your company's main business activity? (e.g. entrepreneur, consulting, operations and maintenance). If your company is made up of several divisions, please make a list of these and specify which division(s) you work in.

3. What is the typical monetary size of your contracts? If the sizes vary greatly, feel free to include approximate numbers for small, average and large size contracts. If you know the annual revenue of your division within your company, please write this as well.

4. What is the typical time span of your contracts? If the time span varies greatly, feel free to include examples of both short term and long term contracts here.

5. What is your job title?

6. Do you identify as part of the construction industry?

7. For how many years have you had your current job title? Please also specify if you've had other jobs in the past that were relevant to your current kind of work, and for how long you had this/these job(s).

8. Does your work mainly involve physical or organizational tasks? Briefly explain, or make a list of typical tasks you are involved in.

Appendix F: Interview guide – English

9. Does your company have a clear policy of safety measures for how to perform your work to maintain EHS (environment, health and safety)? Do you have a written framework for how to safely perform your work? Do you often complete safety courses? How about a safety check-list? Are you ever exposed to dangers that these measures don't provide a clear guidance for handling? Please mention such situations, if you've experienced any.

10. Are you required to have any kind of safety certificate to perform your job? Do you frequently have to renew any such certificates? If so, how often do you do this?

11. Do you know if there exist any common organisation (like e.g. SfS BA for construction companies) whose goal is to improve the safety of maintenance workers? If so, are you part of any such organisation?

12. Have you ever been involved in or witnessed accidents in your job? Or perhaps you've heard of accidents of which your colleagues have been involved in? Please describe roughly what happened.

13. Have you ever experienced or witnessed equipment failures that imposed dangers or accidents? Or perhaps you've heard of such cases by your colleagues? Please make a list of these situations, explain what failures happened, and how the failures imposed dangers in each case.

14. Have you ever experienced, or do you have knowledge of situations where maintenance have been difficult or dangerous to perform due to poor design of the item that were to be maintained, or that the item was installed in a poor manner? (e.g. because of poor accessibility) If yes, please explain.

15. Do you ever have to perform maintenance close to moving parts (e.g. moving cogs in a machine, powerful water streams etc.)? Please describe these situations, and whether this is something you do frequently or not.

16. Do you ever have to remove protective gear to perform the required maintenance? This can either be from the items being maintained or personal protective gear like helmets, climbing harnesses etc.

17. Regarding the question above: Could this be avoided if the items being maintained was designed differently? Or perhaps if the architects/engineers of the building

planned for better maintainability? Please mention specific examples if you've got any.

18. Do you think digitization could help improve your work safety? E.g. by censors detecting when maintenance must be performed, what must be done and where it must be done? If can think of any systems or situations where this would help, please explain here.

19. Have you ever been involved in, or witnessed situations that turned out to be more dangerous than they initially seemed to be? Or perhaps you've heard of such situations by colleagues? Is this something which happens frequently? Please write down specific examples if you've got any.

20. Have you ever been involved or witnessed situations where macho culture has had a negative impact on EHS? Or perhaps you've heard of such situations by colleagues? Please describe these situations if you know any.

21. Have you ever been involved in or witnessed situations where poor communication imposed dangers? Or perhaps you've heard of such situations from colleagues? Please describe such situations if you know any, and whether there are some specific communication problems that occur frequently.

22. Do you have an impression of which underlying causes are usually responsible for accidents in your kind of work? E.g. lack of experience, poor communication, poor safety awareness, unsafe behaviour, poor safety culture, failing equipment, poor equipment design etc. Feel free to mention causes that are not mentioned among these examples, and you can write down more than one cause.

23. Have you witnessed any changes regarding the focus on EHS during your professional career? Please describe such changes if you've noticed any, and specify whether they've had a negative or a positive impact. Feel free to mention anything that you can think of. Whether these changes are of a technical or a cultural nature.