

Managing Health and Safety on the building site

a study on communication
issues between the involved
actors



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Ana Claudia Schneider Hansen
Ioakeim Kolokotronis

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Thomas Manns Vej 23

9220 Aalborg Ø

byggeri.aau.dk

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Authors:

Ana Claudia Schneider Hansen
Ioakeim Kolokotronis

Supervisors:

Ekaterina Petrova
Kjeld Svidt

Censor:

Søren Wandahl

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Synopsis:

This master thesis investigates how communication among the different involved actors affects the onsite health and safety.

The construction industry is regarded as a business sector in constant development, leading to increased employment and economic prosperity. This industry is also known as one of the most dangerous industries all over the globe, which means that the building site manager and the project manager have to combine forces in order to develop an appropriate H&S plan so that this plan will be strictly followed. At the same time, they should cooperate with the H&S manager in accordance with the H&S rules and regulations. During the construction period, the workers with different backgrounds (trades, cultures, educations, languages) come across communication barriers within H&S messages. Therefore, proper and effective communication among these different actors is crucial.

This study will research how communication can be improved, how feedback is used within the different trades, how injuries and deaths are reported and how the right measures are taken in order to improve safety on site during the timeframe of the construction.

The main objective of this report is to underline the importance of the communication between the involved actors and provide suggestions of how this can be further improved. This study is carried out by systematic literature review and qualitative interviews.



Abstract

The purpose of this master's thesis is to investigate how safety communication can affect safety on the building industry. The construction industry as a whole is one of the most injury industries where productivity is a priority rather than safety.

The methodology used in this report is Pragmatism with deductive approach. By using interviews as a qualitative method, where two interviews were conducted with people from the Danish construction industry. The use of quantitative method can be seen where numerical data is used in the tables and statistics.

The interviews were semi-structured which allowed the interviewer to explore other topics that surfaced on the interviews.

Communication is a factor that contributes positively in safety on the building sites.

A literature review created the foundation for the research. The systematic literature review was the basis for exploration of what safety communication, safety culture, risk management, safety climate, accidents, safety management, ICT and BIM tools are and what barriers exist currently in the construction building sites that are hindrance for effective communication, as well the effect of COVID-19 as an actual health issue on the building sites.

The thematic analysis was used to analyse the interviews, since it is an effective method to extract data from the interviews.

At the same time, the managers and the foreman should prioritize safety communication with the participation of the construction crew during meetings or briefings.

In the discussion, the notions from the literature review are converged with the findings from the data analysis served as the basis for the development of a framework for construction safety on the building sites that was proposed together with overall recommendations for the construction industry. Safety on the building sites can be achieved by following a checklist developed in connection with the construction safety framework in a form of a flowchart.



Preface

This master's thesis is written in cooperation by Ana Claudia Schneider Hansen and Ioakeim Kolokotronis from 1st February to 10th June 2020, during the fourth semester of the Master Programme Management in the Building Industry at Aalborg University.

The master's thesis investigates how communication issues between the different actors involved in a construction project can be dealt with. This report contains seven chapters; Introduction, Methodology, Literature Review, Problem Formulation, Data Analysis, Discussion and Conclusion. There are included appendices at the end of the report where the interview questions and interview guide, and other relevant documents can be found.

The students appreciate the efforts and supervision given by Ekaterina Petrova and Kjeld Svidt during this semester.

The students would like to express their gratitude to Vincent Maes and Mia Hansen for their contribution for this research.

Readers' guide

Structure of the master's thesis

The structure of this master's thesis is based on Aalborg University's problem based learning pedagogy known as PBL. The thesis consists of eight chapters, organised as shown in Figure X.

In this report, the chapters begin with a small explanation on the main purpose of the aforementioned chapters.

Chapter 1 outlines the thesis background highlighting briefly the relevant research that has been done so far in the subject area, the knowledge gap that exists and the reasoning for this study.

Chapter 2 presents the aim and objectives of the paper, the structure of the research, the research design and the major contributions of the study to obtain relevant knowledge.

Chapter 3 gives an in-depth review of literature studies in the H&S area of subject and the accident causal role of onsite miscommunication. It establishes the extent to which the incident and fatality rate has been explored previously in literature and consequently reveals the connection related to how proper onsite communication decreases the occurrence of injuries on the building sites.

Chapter 4 provides the answer for the initial problem formulation and the final problem statement for this research.

Chapter 5 gives the data analysis of the qualitative interviews conducted during the research study and the findings of the qualitative inquiry.

Chapter 6 outlines the discussion of the findings and results of this research .

Chapter 7 draws a conclusion of this master's thesis based on the analysis of the data collection, literature review, results and validation of the findings.

At the end of this master's thesis, are included both a list of the bibliography used for the study and the appendices. In the appendices, named after the information that is provided in each individual one, can be found:

- Questions for the interviews
- Interview guide
- Field notes for the qualitative Interviews

The report utilises the Harvard method for the references and citations.

The report contains abbreviations that have been used often in the text. The first time the word is found in the text it is shown in full, followed by its abbreviation, afterwards the abbreviation for that word is shown in the progression of this report.

Aalborg, June 2020

Ana Claudia Schneider Hansen and Ioakeim Kolokotronis,

Keywords: Barriers, Building site, Construction safety, Communication, COVID-19, Digitalization, Health and Safety, Management, Risk, Safety communication, Safety culture, Training.



List of Abbreviations

| Abbreviation | Explanation |
|---------------|---|
| BAT-kartellet | Bygge- Anlægs- og Trækartellet |
| CAD | Computer Aid Design |
| COVID-19 | Coronavirus |
| DKK | Danish Crowns |
| EDI | Electronic Data Interchange |
| H&S | Health and Safety |
| HSE | Health, Safety and Environment |
| HSE | The United Kingdom Health and Safety Executive |
| ICPM | Internet based Construction Project Management |
| ICT | Information Communication Technology |
| ILO | International Labour Organisation |
| MIS | Management Information System |
| OHSAS | Occupational Health and Safety Assessment Series |
| OH&S | Occupational Health and Safety |
| PBL | Aalborg University's theory of problem based learning |
| PDCA | Plan Do Check Act |
| PPE | Personal Protective Equipment |
| RA | Risk Assessment |
| SARS | Severe acute respiratory syndrome |
| UK | United Kingdom |
| VR | Virtual Reality |
| WEA | Danish Work Environment Authority |
| WEO | Working Environment Organization |
| WET | Working Environment Team |
| WHO | World Health Organization |



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Introduction

This chapter gives an overview of the subject area of this research, by presenting the problem field and by providing the initial problem statement of this paper.

The construction industry includes the building, civil engineering, maintenance and demolition industries and it is seen as an industrial sector in constant and continuous development. Globally, the building industry employs a large percentage of the labour force. ([International Labour Organisation, 2015](#)) Furthermore, the building sector plays a major role in economic growth worldwide. ([Dlamini, 2012](#)) Nevertheless, this industry is identified as the most injury-prone industry too. ([Fang and Wu, 2013](#)), ([International Labour Organisation, 2015](#))

Therefore, the safety at the construction workplace is an area of major concern for this industry, simply because there is still a rise in reported fatalities and situations where a construction worker is at risk of an illness, injury or even death. Thus, it is of the utmost importance to reduce the number of these injuries, deaths and illnesses related to the construction sector by the implementation of the Health and Safety, from now on expressed H&S, on the building sites.

Despite substantial efforts to improve safety on the construction sites, in Denmark, 5.296 accidents had been still reported in the construction sector in the year of 2017, out of this number, 1.100 accidents were reported as serious that resulted in a total of 4 deaths. ([Dagensbyggeri, 2018](#)) Likewise, similar patterns have been reported in many other countries around the world. ([Pandit et al., 2019](#)) The construction accidents related to the H&S outcomes result in extra costs on the industry ([Pearce, 2003](#)), productivity losses, and unpleasant emotional and psychological distress caused to the construction workers, families, and co-workers of these affected workers ([Yuan et al., 2018](#)), ([Waehrer et al., 2007](#)), ([Zou and Sunindijo, 2015](#)), as well delays in the construction completion and even reputational harm of the contractors. ([Wang et al., 2006](#)) Therefore, there is a demand for mastering how these injuries and deaths can be minimized by the use of simple methods like communication of safety rules among construction crew and better and effective training of the staff. ([Pandit et al., 2019](#))

The terms safety culture, safety management, safety communication and safety climate are altogether now commonplace in the construction industry, as well in other important industries such as aviation, petrochemical, oil and gas and so on.

Over the last years, major improvements in organizational safety performance have been reached. However, many organizations still struggle moving beyond current safety performance plateaus. Therefore, it is beyond critical to optimize safety management in order to reduce the number and severity of injuries and at the same time to improve the safety culture within the organisation. ([EHS Today, 2017](#))

This research addresses those concepts and gives an overview of safety communication and its tools, communication and safety culture, as well as different communication styles through a

review in the relevant literature.

Thus, this paper highlights the importance of onsite safety communication in order to decrease the cases of incidents in the construction industry and shows ways to improve safety management. Furthermore, it aims to assist the reader in understanding those terms, likewise to make informed decisions of organisational safety.

1.1 Defining Communication

The definition of communication is broad, since it depends on the individual's viewpoint and multidimensional context, and it includes body language as well. Yet, the word communication is normally defined as the action of communicating by the transmission of messages, dissemination of information by the use of specific methods. (Mifflin, 2000) The meaning of communication in the American Heritage Dictionary is:

The exchange of thoughts, messages, or information, as by speech, signals, writing, or behavior. (Mifflin, 2000) (1)

However, the communication in the construction industry has another connotation thus a complex concept, due to the fact that an abundance of different communication takes place concurrently. (Dainty et al., 2007)

Moreover, communication can be the key component for the success of a project or it can cause issues if it is indeed poor. Miscommunication can affect, in a variety of ways, the construction industry like failing to follow the timetable, quality of the final construction, legal matters, budgeting and of course, safety. (Hoezen et al., 2006)

In addition, misunderstandings can occur as a result of unclear handwriting, misused terms, or incomplete drawings and documents. While diversity in the construction sector is at an all time high, cultural and language differences can also make confusion and mistakes to happen. Even people with the same ethnic background, the possibility of having such issues is quite high due to semantics and interpretations. (Lets Build, 2019)

1.2 Safety Communication

Safety communication is related to the procedures and rules at the workplace, regulations, performance statistics, hazard and accident reports, risk assessments and construction workers' training. By ensuring prompt and effective communication during the construction period on the building sites, the construction staff engages into a safer daily practice on the work-site, ensuring cooperation among the team while keeping a positive safety culture. (Vecchio-Sadus, 2007)

Safety communication among staff is seen as a crucial tool to reach a satisfactory safety management. (Pandit et al., 2019) However, poor safety communication is still an occurring issue on the construction sites that leads to many injuries. (Albert and Hallowell, 2017), (Allison and Kaminsky, 2017), (Chan et al., 2016), (Alsamadani et al., 2013).

1.3 Onsite H&S

The Danish Working Environment Authority, WEA, also known in Danish as Arbejdstilsynet is a government agency which is responsible for occupational H&S and inspection of working conditions in Denmark. Moreover this agency covers foreign companies that have commercial activities in Denmark. While it also providing guidance the WEA which can notify the companies for violations of the rules and at dyer cases it has the authority to seize a construction site if the hazards are serious. The ultimate goal of WEA is to minimize the work-related accidents, deaths and illnesses in the Danish labour market. (WEA, 2020)

1.4 Presentation of the problem field

Many different researchers revealed through H&S statistics, that the injury and fatality rates in the building sector are higher than the other sectors of the industry in the majority of the world countries. (Hinze, 2005) (Smallwood and Ehrlich, 2008) (Lingard and Rowlinson, 2005)

As mentioned previously, the building industry employs a large percentage of the labour force. (International Labour Organisation, 2015) In Denmark, the number of construction workers in the first quarter of 2019 was 179.000, whereas the construction crew accounted in the first quarter of 2020 (before the beginning of the outbreak of the novel coronavirus) 180.700, as shown in figure 1.1 (Danmarks Statistik, 2020b), therefore the need of measures of prevention of accidents on the building sites is extremely relevant to the construction segment.



Figure 1.1. Employment in the Danish construction industry from years 2006-2020 (Based on (Danmarks Statistik, 2020b))

According to International Labour Organisation (2015), around 108.000 building workers die on the construction sites every year, which is 30 % of all fatal work related injuries. Due to the fragmented nature of the construction industry and to the multiple stakeholders involved in a construction project, it is not difficult to grasp that the statement from International Labour Organisation (2015) is accurate.

As stated by Siew (2015) poor communication on H&S issues is the reason of the injuries in the building sector and it is therefore pointed out that communication is considered as a challenge on the construction sites.

In fact, one of the most practical methods to prevent onsite incidents and improve safety culture within an organisation is to enhance safety communication in the organisation. (Williams, 2003)

Actually, in times like now, where the coronavirus, from now on called COVID-19, pandemic is taken the globe by storm, communication can either improve or impair the H&S program of the company. The unexpected and sudden arrival of COVID-19 outbreak in early 2020 has also given the construction managers a priceless hint that prompt, suitable and effective safety communication is the solution for the proper compliance of onsite H&S even during the H&S interruptions. (EHS Today, 2020)

1.5 Initial problem statement

Since the main concern of this research is to provide ways of decreasing the amount of incidents in the construction industry and due to the fact that poor communication is considered one of the reasons leading to injuries onsite, it seems therefore compelling to investigate how a company in the building industry can improve its communication, which leads to the following initial problem statement:

*How can effective communication improve safety culture
in the building industry?*

The initial problem formulation considered in this chapter focuses on the existence of causes for the rise of incident and fatality rate in the building industry. That being said, this initial problem statement leads the research found in this report towards effective communication. The reasoning for this study is to provide knowledge in the subject area, especially in order to suppress the knowledge gap within ways to ensure effective communication in the building industry. In addition, chapter 3 provides a systematic review of the actual literature which provides a solid foundation for unveiling the final problem statement of this study.

Methodology

This chapter presents the adopted research design for the empirical investigation. In this study, the authors used pragmatism as the philosophical worldview and qualitative strategy as the research inquiry. The justification for these approaches and the procedure for data collection are also presented further on.

2.1 Research design

According to Creswell (2009), the terminology **research design** means the plan and procedures used to conduct a research. By doing so, the research involves the intersection of 3 elements that are relevant for this study, such as the philosophical worldview (methodological paradigm), strategies of inquiry (research strategies) and specific methods (research methods). Thus, a research design can be divided in 3 types that are most common used nowadays, for instance qualitative, quantitative and mixed method. (Creswell, 2009)

Creswell (2009) suggests, in order to select the appropriate type for a given research, that the decision should be based by the 3 elements of the research design. In the figure 2.1, a tripartite framework is shown and used as a tool, in order to aid the choice of the best research design for this thesis.

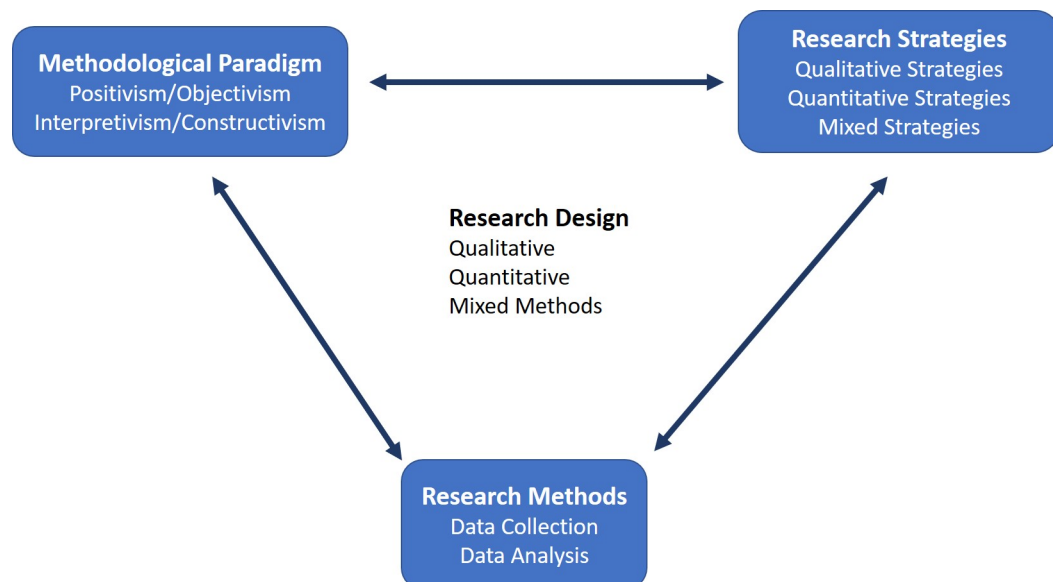


Figure 2.1. Research Design (Based on (Creswell, 2009))

2.1.1 Philosophical worldview

Creswell (2009) uses the term, *philosophical worldview* instead of methodological paradigm, however Guba (1990) defines paradigm as an interpretive framework, *a basic set of beliefs that guide action*.

There are four philosophical worldviews: Constructivism, Postpositivism, Pragmatism, and Advocacy/Participatory. Each of these philosophical worldviews have different approaches to the research. The selection of a worldview is very important because it dictates the structure and guide of the report. The methods that will be used in a research are indicated by the worldviews. Therefore, the methods that are to be used are not totally compatible with all the worldviews. Qualitative and quantitative methods should be considered differently for each worldview. (Creswell, 2009)

Pragmatism

As stated by Creswell (2014), *"the pragmatist researchers look to the what and how to research based on the intended consequences — where they want to go with it."*

In this report, the worldview used is pragmatism. In the pragmatism, the knowledge derives from actions, situations, and consequences. The concern is focused on "what works" and solutions to the problems. It should be mentioned that in pragmatism there are not specific methods or techniques used. As a result mixed methods are used instead of one exclusively. This can give to the researcher the opportunity to use multiple approaches to the problem. Therefore both quantitative and qualitative methods are used. (Creswell, 2009)

2.1.2 Research Strategy

Researchers adopt a research strategy and research methods for collecting and analysing data. The research strategy or strategy of inquiry, provides specific direction for procedures in a research design (Creswell, 2009). The three common research strategies are known as qualitative, quantitative and mixed method strategies. (Creswell, 2009)

As previously shown in figure 2.1, the research strategy is based in either qualitative or quantitative methods or mixed methods which are the use of both qualitative and quantitative methods. (Creswell, 2009)

Qualitative and Quantitative Methods

The qualitative methods use non-numerical data to acquire the characteristics in depth. Therefore when the researcher makes use of a qualitative method the main effort focuses on investigating the different aspects of a subject. On the other side, the quantitative methods are based on numbers and quantifies the data. In order for a researcher to make use of quantitative methods, the elements that are researched must be countable. (Johnson and Kristensen, 2008)

In this master's thesis, both qualitative and qualitative methods are used. Qualitative interviews based on an interview guide are conducted, see Appendix B on page 103, with people across the building industry which can be considered as a qualitative method because the data from the interviews that will be analysed, are non-numerical. In addition, the quantitative method is used in the literature review. The numerical data that that are presented in the report can be considered as a quantitative. Therefore, the statistics that are presented in a form of graphs or tables derive from numerical sources.

Inductive and Deductive

The basic difference between induction and deduction approaches is that the induction approach begins with the collection of data in order to construct a theory, while the deduction approach is starting with a theory and it tries to prove it with the previous collected data. This can be seen in figure 2.2. (Gabriel, 2013)

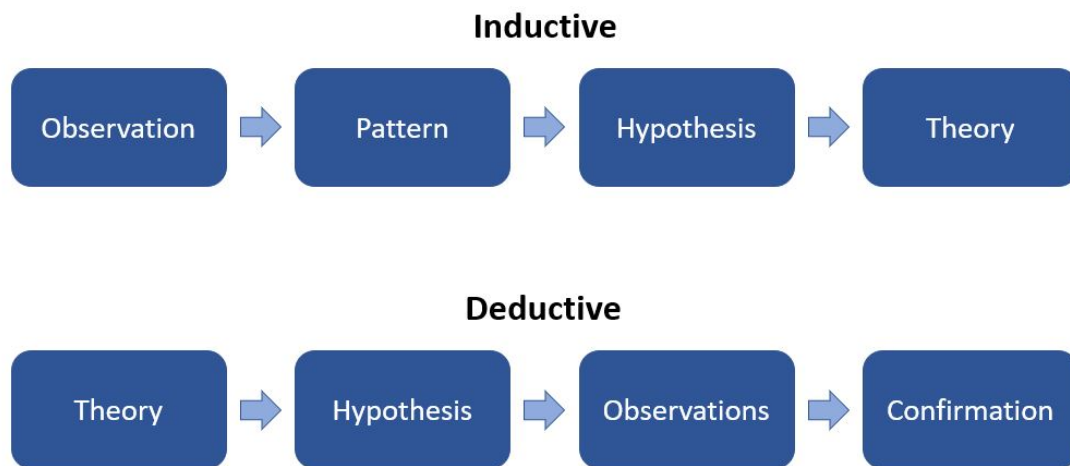


Figure 2.2. Inductive and Deductive approach for research (Based on (Gabriel, 2013))

In a deductive approach the case starts with an (assumption) theory, whereas in an inductive case the scope is limited with questions. In the inductive approaches, it is usually used qualitative research methods, while deductive approaches are leaning more to quantitative research methods. This is not the rule though, there are some cases that qualitative cases can have a deductive approach. (Gabriel, 2013)

The deductive approach is involved with creating a hypothesis that is based on an existing theory. The next step is to design a research strategy to put the hypothesis into questioning. (Jonathan, 2014)

The deductive approach takes the research subject from the particular to the general. This design can test so that can prove if the connections made (from the particular to the general) apply on more general circumstances. (Gulati, 2009)

According to Gulati (2009), there are advantages that derive from using that approach among others which can:

1. Explain casual relations among concepts and different variables;
2. Measure concepts quantitatively;
3. Generalize research findings up to a certain extend;

Choice between inductive and deductive approach for this report

The deductive approach explores a known theory and tests if that specific theory is valid under the given circumstances. It is also suggested to use this approach when there is abundance of sources, short time availability, and avoidance of risk. On the contrary, the inductive approach can be used when there is scarcity of literature, plenty of time available, and the risk factor can be

acceptable, because there is a possibility that a theory might not emerge. (Snieder and Larner, 2009)

The criteria above lead the researchers to choose the deductive approach. This can be the most plausible way to conduct the research for the present report. The characteristics that appeal to this specific research are among others, the abundance of bibliography, this can be seen in the literature review, chapter 3 on page 13 and also the restriction of time, where this research has a limited time frame.

2.1.3 Research methods

2.1.4 Data Collection

This master's thesis takes offset in both *primary* and *secondary data collection*. In accordance to MacDonald and Headlam (2008), the primary data consists of interviews, observations and documents provided by the researchers, whereas the secondary data is any other data gathered by others than the researchers such as statistics and literature.

Usually in research the key information can be poorly reported in systematic reviews. It is known that systematic review should be accessed fully and have in display their limitations, weaknesses and strengths. For that reason QUOROM was developed the initial form of PRISMA. As seen in 3.1 on page 13, it starts with the research results on the top and it narrows down to the actual sources that were used in this report. PRISMA emphasises on ways that the researchers can ensure the transparent and complete reporting of systematic reviews and meta-analysis. In addition, the analysis does not happen in detail and does not elaborate on the conduct of systematic reviews. PRISMA was developed for healthcare studies, but it can be used as well as a research tool for other studies. (Moher et al., 2009)

Interviews

An interview study was undertaken in order to unveil challenges at construction workplaces related to onsite H&S and occupational injury risks in connection to safety communication and safety culture. The interviews were the primary data collection method used in this study. As appointed by Yin (2003), the interviews are known as a very effective data collection method when gathering a vast amount of data.

Yet, some research themes were chosen as the major focus during the interviews: general questions, safety culture, existing practices, safety communication, safety management, Building Information Modelling or BIM, migrant workers and COVID-19. An interview guide was prepared with these different 8 key categories with a total of 31 questions.

All the questions for the interviews were semi-structured, divided into different categories, which gave the chance, to the interviewer, of asking some additional questions around the relevant topics, as well the possibility of exploring new information, given by the interviewee, during the actual interview. (Bryman, 2012)

The technique used for preparing the content for the interviews, its questions and the way that the interviews were conducted, the transcription method and further steps take offset from the 7 interview stages proposed by Kvale (2008).

In order to gain insight in communication problems, interviewees with experience on the

construction sites were interviewed. The interviewees were selected based on their profession and the type of building projects they were working at the moment.

Furthermore, these interviews were conducted in April and May 2020 by video call or over the telephone. The length of each interview ranged from 50 minutes up to an hour, but the majority lasted about 50 minutes. All of the interviews were recorded, in order to provide a reliable source and an adequate quality of data. During the interviews, field notes were made, which were transcribed directly after each interview. See Appendix B on page 103 for field notes.

The qualitative interview

The research team chose a qualitative interview in order to collect data for the analysis. In an attempt to increase the validity of the interview, an interview guide was used. Therefore the interview guide is a table in which the first column presents the frame of reference, the second column the reflections made, and in the last column are found the questions that will be asked to the interviewee. The interview guide used for this report can be seen in Appendix B on page 103.

In addition, the 7 steps of Kvale (2008) will be used for the interview. There are seven steps as seen on figure 2.3.



Figure 2.3. The seven steps for interview (Based on (Kvale, 2008))

1. Thematising: The purpose of the case is taking a form and the topics of study are clarified.
2. Designing: Designing decisions are made in that step whether the interview will be qualitative or quantitative, and the structure of the interview. In that step the interview guide is created.
3. Interviewing: The interview is made between the interviewer and the interviewee.
4. Transcribing: The transcribing step is made to prepare the text that will be analysed.
5. Analyzing: The methods for analysis is chosen in that step along with the use of the data from the interview.
6. Verifying: The reliability and validity of the results are tested.
7. Reporting: Finally the findings and methods are presented, along with interpretations.

Literature review

The main focus areas of this master's thesis are communication, H&S on the building sites and the building industry.

The first assumption is that there is a connection about injuries and deaths on the construction sites and communication of H&S risks. Therefore, the research team started a systematic literature review upon these main focus areas, in order to obtain a clear view of the current situation of injury and fatality rate on the building sites, and at the same time in order to gain knowledge about key terminologies, and gather ideas of measures for improving communication and safety on the building sites.

By performing a literature review, either this assumption above would be validate or not, which would aid the researchers towards the identification of a gap on the current literature.

Nonetheless, the first step for collecting the relevant qualitative data for this research was the search of literature through a digital search in many different electronic databases. This search started with keywords like for instance: communication, safety on building sites, injuries on the building sites, communication and safety on building sites so on, used for searching in different databases (AAU library, Google Scholar etc), in order to identify the relevant material for this research.

It is important to bear in mind that many articles were disregarded, since those articles were not related to the building industry, nor H&S on building sites.

Once the researchers came across the relevant literature, these papers were then gathered for a further discussion in order to be used or not as sources for this thesis.

2.1.5 Data Analysis

The qualitative data analysis is defined by [Bogdan and Biklen \(2003\)](#) as:

“working with the data, organising them, breaking them into manageable units, coding them, synthesising them, and searching for patterns”. (2)

Therefore, one may say that the aim of the qualitative data analysis *is to discover meanings, themes, patterns and concepts.* ([Patton, 2002](#))

During the data analysis procedure, data collection was not ceased, so that new information was sought until no more new data about the relevant topics was found.

Thematic Analysis

A method to analyze qualitative data can be thematic analysis. In that method the researcher examines the data in order to detect common themes, patterns that come up repeatedly. ([Nowell et al., 2017](#))

Thematic analysis can be segregated in 6 phases as seen in: 2.4 on the next page.

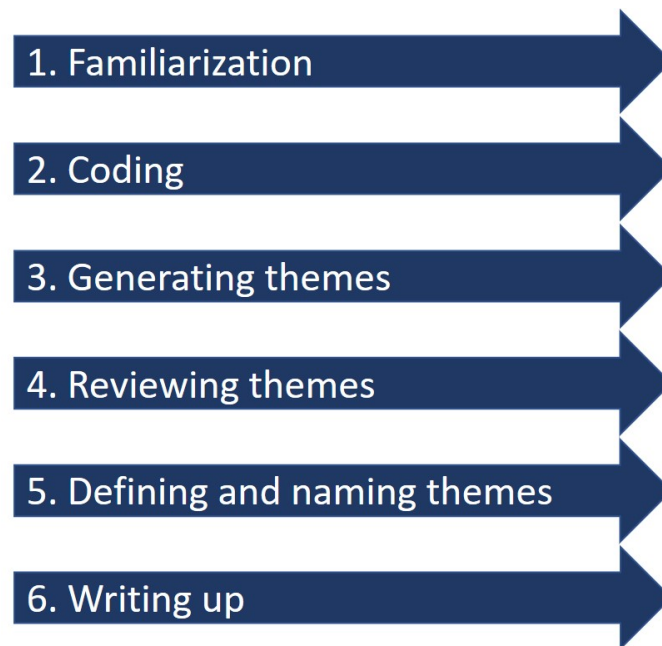


Figure 2.4. The six steps used in thematic analysis (Based on Nowell et al. (2017))

Using thematic analysis, the researchers have the opportunity to find out people's opinions, experiences, views or values by analysing qualitative data like interviews, social media profiles, or survey responses. Nowell et al. (2017) claims that this type of analysis allows to approach large data sets by organising them into broad themes.

1. **Familiarization:** The first step is to get to know the data. It is very important to get a really good view of the data before starting to analyse them.
2. **Coding:** On this step, the data are getting a form by coding them. Phrases or sentences are highlighted in order to define their content.
3. **Generating themes:** The next step is to generate themes by looking at the codes that were created in the previous step. Usually themes are much broader than codes and they can combine various codes under one theme. Moreover, some of the codes can lose their relevance and they can be eliminated.
4. **Reviewing themes:** In this step, the researchers have to make sure that the themes are represented accurately. A comparison between the data sets and the themes is taking place in order to make sure that they are compatible. It is possible to make changes to the themes also in this phase.
5. **Defining and naming themes:** When naming the themes, the researchers have to come up with a concise and distinct name. Also a definition should be given to the themes in order to be understandable to the readers.
6. **Writing up:** Finally, in the last step, the data that were analysed are presented. In the findings section, the themes are addressed and a description of them is included.

Reliability and Validity

When it comes to reliability and validity, there are some challenges related to the qualitative research. In response to these recognised challenges, Yin (1994) proposed the application of 3 tests in order to appraise the quality of research designs such as: *internal validity*, *external validity* and *reliability*.

Paraphrasing the notion of *internal validity* given by Bryman (2004) , where this notion *is related to causality, to the question of whether a conclusion that incorporates a causal relationship between two or more variables holds water*, whereas the *external validity* is related to whether or not the findings of a particular research are generalised beyond the specific research context. (Bryman, 2004)

As Joppe (2000) claims reliability is as weather the results are consistent over time and if the study would be repeated with similar methodology, would it lead to the same results.

Reliability is a term usually used for quantitative situations but this is not absolute. If a report has increased reliability, the subject can be understood easier by the readers and explain a situation that otherwise would be very difficult to understand. (Golafshani, 2003)

Source Criticism

The researchers tried to increase the report's reliability by using sources of data from Danish government agencies like: the Working Environment Authority (WEA) and the Danish statistic authority. In addition, international agencies were included like: International Labour Organisation (ILO) and the World Health Organisation (WHO). By following this practice, the research team tried to use the most widely reliable data for the present report.

Limitations

The focus of this study is limited only to the Danish construction industry. Yet, it is also expected that this research will come from studies on the building industry of other nations too. The causes of construction accidents are considered as a complex and multi-faceted situation which involves a bunch of multiple and interconnected causal factors. Therefore, the main theories of construction incidents and its causes are not covered by this paper. Thus, due to the relative limited research focus on other topics than onsite H&S, this research focuses on the causal factors which emanate from the barriers of communication among the involved actors working together on a construction project. The study uses limited sample size of data collection methods due to both the COVID-19 outbreak, and respectively, the society lockdown, and time constraints.

Literature Review

In the chapter 3, a literature review upon health and safety situations on construction sites is further discussed. This chapter commences by highlighting the current situation of health and safety hazards worldwide and showing how the outbreak of COVID-19 is affecting the building industry in Denmark and disrupting workflow on building sites, followed by the definition of terminologies, the main sources of accidents, as well related ill problems on construction sites and their costs. A depth discussion on organizational culture, safety culture and climate as well safety communication and communication barriers are also provided.

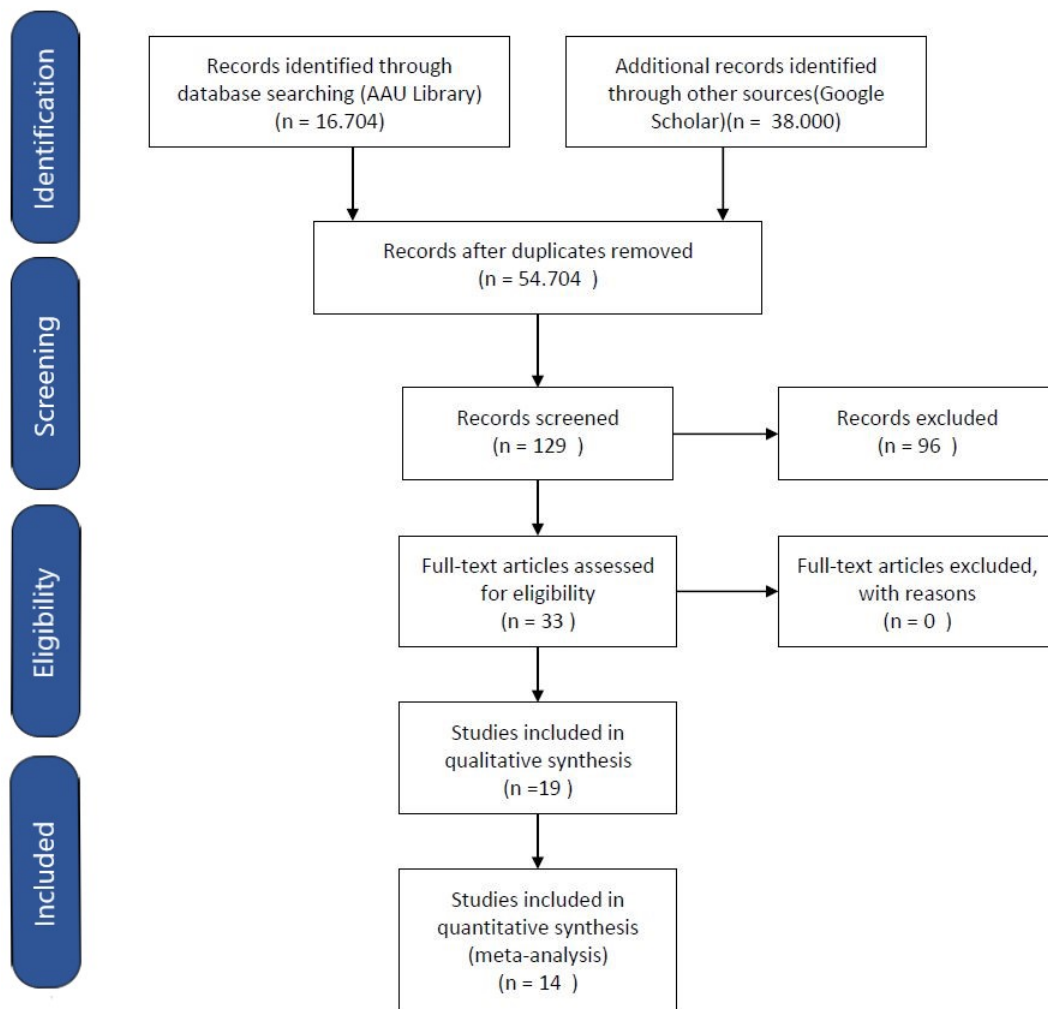


Figure 3.1. PRISMA flow diagram (Based on (Moher et al., 2009))

The PRISMA flow diagram was used in order to find relevant literature for the different subjects

that are presented in this report. Keywords like safety culture, safety communication, accidents, cost of injuries, H&S rules, risk assessments, safety management, organisational culture etc were used to initiate a research. The search results of two main search engines were reduced gradually to the point that the research team made the selection of the sources that would be used in this report. This process can be seen in figure 3.1 on the preceding page. The example found in figure 3.1 on the previous page describes the steps of finding *safety communication* as the first approach of the search for literature.

3.1 Health and Safety risk worldwide

H&S risks in the building sector are always a major concern for both practitioners and researchers worldwide. Since, the construction sector is recognized as the most hazardous workplace, it explains the fact of the existence of a high level of H&S risks spotted onsite. (Lingard and Rowlinson, 2005), (International Labour Organisation, 2015), (Smallwood and Ehrlich, 2008).

According to International Labour Organisation (2015) *at least 108.000 workers are killed on site every year, a figure which represents about 30 per cent of all occupational fatal injuries. Data from a number of industrialized countries show that construction workers are 3 to 4 times more likely than other workers to die from accidents at work. In the developing world, the risks associated with construction work may be 3 to 6 times greater. Many more workers suffer and die from occupational diseases arising from past exposure to dangerous substances, such as asbestos.*

On the same page, many researchers have presented statistics on onsite H&S showing that, the injury and fatality rates in the building projects are higher, when compared to the other industries in the majority of the countries analysed in these studies. (Lingard and Rowlinson, 2005), (Smallwood and Ehrlich, 2008), (Hinze, 2005).

In fact, Sousa and Teixeira (2004) stated that workers from the construction industry worldwide are 3 times more prone to die and 2 times as likely to be injured onsite in comparison to any other worker involved in any other economic activities.

COVID-19 outbreak

The origin of the outbreak of COVID-19 is the city of Wuhan, Hubei Province in China (Li et al., 2020), (Tan et al., 2020), (Zhu et al., 2020), where the first four initial cases were reported and linked to the Huanan Seafood Wholesale Market. (Li et al., 2020) The local hospitals identified the virus by the use of a surveillance mechanism for *pneumonia unknown etiology*. (Xiang et al., 2013), (World Health Organization, 2020a). Since the outbreak of severe acute respiratory syndrome, known as SARS back in 2003, the medical field established this surveillance mechanism for the prompt identification of novel pathogens such as COVID-19. (Xiang et al., 2013) However, *pneumonia of unknown etiology* is defined by Xiang et al. (2013) as *an illness without a causative pathogen* with the following symptoms:

- Fever above 38 °C
- Evidence of pneumonia by an X-ray examination
- Low or normal white-cell count or low lymphocyte count
- No symptomatic improvement after antimicrobial treatment for 3 to 5 days following standard clinical guidelines

However, the most common symptoms (Wang et al., 2020), (Ren et al., 2020), (Huang et al., 2020), (Carlos et al., 2020), (CDC, 2020) at onset of COVID-19 sickness are: fever, cough, headache and flu-like symptoms.

The symptoms of COVID-19 normally appear after an incubation period of approximately 5.2 days. (Li et al., 2020) This virus is one of the pathogens that predominately attacks the human respiratory system. (Rothan and Byrareddy, 2020)

Several studies suggested that the virus is likely spread by person to person contact. This insinuation is further supported by the fact that the infection cases that occurred within families and among people who did not visit the seafood market in Wuhan. The transmission occurs, therefore, primarily via direct human contact or through droplets spread by coughing or sneezing from an infected person. (Carlos et al., 2020), (Wu et al., 2020)

So, the general advices in order to limit the spread of the infection in the country, given by the Danish Health Authority, or Sundhedsstyrelsen in Danish, are to:

- Wash hands often or use hand sanitiser
- Decrease physical contact
- Cough or sneeze under the sleeve
- Clean the house regularly and be diligent with own hygiene habits
- Keep safe distance of others when outside
- Avoid visiting elderly and chronic sick family members and friends (Sundhedsstyrelsen, 2020)

There are general advices provided by Workplace Denmark (2020), in order to prevent the spread of the infection on construction sites such as for instance: distance from the workers, wash basins or hand sanitiser available on sites, minimize physical contact, and regular cleaning.

Already on 9 January 2020, World Health Organization (2020e) released a statement on the cluster of cases: *Chinese authorities have made a preliminary determination of a novel (or new) coronavirus, identified in a hospitalized person with pneumonia in Wuhan.* The virus was initially referred to as 2019-nCoV by World Health Organization (2020c) on 21 January 2020.

On 31 January 2020, the World Health Organization (2020f) declared the outbreak of COVID-19 to be a public health emergency of international concern. World Health Organization (2020b) re-named the virus to COVID-19 on 12 February 2020. Due to the fact that the virus widely spread to many countries over the globe, affecting every continent, thus, at the beginning of March 2020, there were more than 113.000 confirmed cases and more than 4.000 deaths from COVID-19 (World Health Organization, 2020d), the World Health Organization (2020g) announced that the COVID-19 outbreak is a pandemic on 11 march 2020.

The first case of COVID-19 in Denmark was confirmed on 27 February 2020. The number of cases in the country significantly increased at the beginning of March. (Statens Serum Institut, 2020)

In response to the pandemic, measures like the society shutdown, including home isolation and quarantine orders and the restriction on gathering people in the public and private spaces were taken in the majority of the countries around the world, inclusive in Denmark.(Regeringen, 2020)

However, the direct health effects on the workers from the outbreak are not the only ones, which can cause an impact on the health of the workers. The restrictions imposed by the governments including the temporary closing of factories, restaurants, hairdressers and other liberal professions, as well the reduction in the workforce at some companies, will more likely cause a major effect in the global economy by the inception of a global financial crisis much more worse than the one experienced in 2008-2009.(Sim, 2020), (Politiken, 2020)

Since the announcement of the lockdown in Denmark on 11 march 2020, including the closing of the country borders on 13 March 2020, the number of workers that have lost their jobs, due to COVID-19 crisis, continues to increase, even though the Danish government has given state aid to the companies in order to minimize the economic impact of the work disruption caused by the outbreak.(Dansk Erhverv, 2020) Since the beginning of the *corona crisis* in Denmark on March 11, 2020, the number of unemployed individuals in Denmark has increased. While there were 131.742 unemployed people on 11 March 2020, the number rose to nearly 179.000 as of 22 April 2020.(Styrelsen for Arbejdsmarked og Rekruttering, 2020) See figure 3.2.



Figure 3.2. The effect of COVID-19 on Employment (Based on Styrelsen for Arbejdsmarked og Rekruttering (2020))

In comparison to the unemployment numbers for the same period of time (9 march to 22 April), during the years 2015 and 2020, it is clear that the outbreak of COVID-19 is hitting hard the economy in Denmark, since there are already 89.602 unemployed people in 2020, as shown in figure 3.3 on the next page.

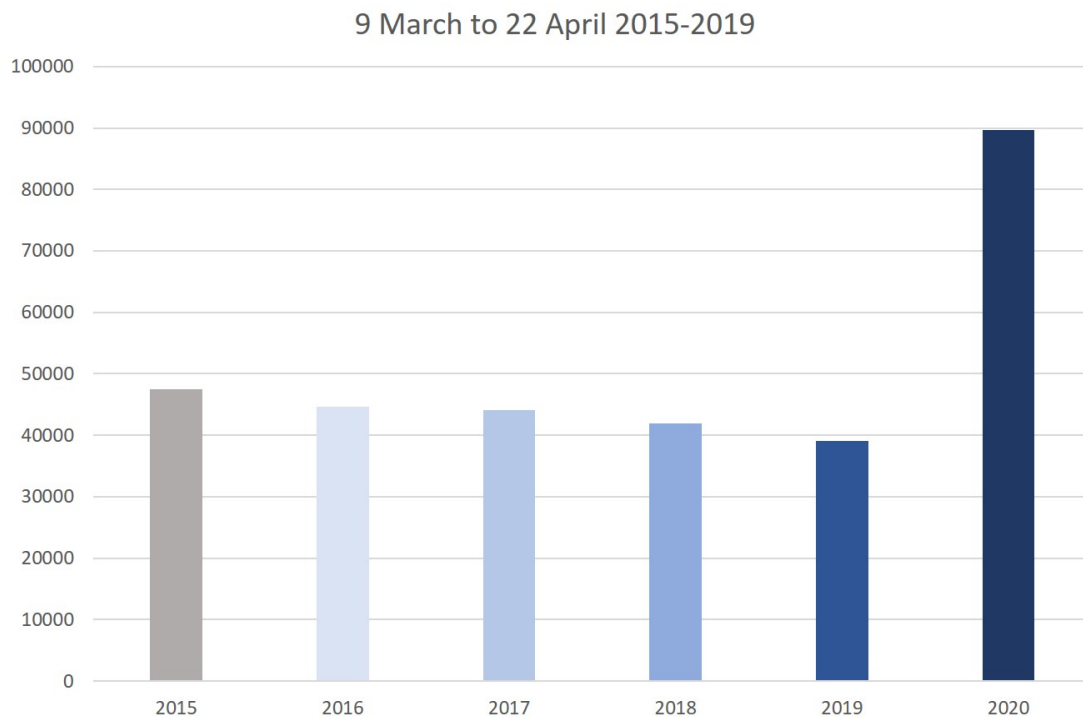


Figure 3.3. Unemployed people every year for the period 9/3 to 22/04 from 2015 to 2020 (Based on Styrelsen for Arbejdsmarked og Rekruttering (2020))

A recent study conducted by Koh (2020) reported that in addition to health care workers, there are other groups of workers who are at increased risk of COVID-19 infection through their work namely the construction crew. (Koh, 2020) Paraphrasing Koh (2020), *COVID-19 is the first new occupational disease to be described in this decade.*

However, as shown in table 3.1, the construction industry in Denmark is less affected due to the spread of the infection in comparison to other segments like for instance services and retail. Danmarks Statistik (2020a) made a study about the effects of the spread of the disease on the different sectors of the Danish industry. The questions to be answered were:

"How has your company been affected by domestic and foreign restrictions related to the Coronavirus?" (3)

| Unit: weighted percentages | Industry | Construction | Services | Retail |
|----------------------------|----------|--------------|----------|--------|
| Not affected | 6 | 12 | 7 | 5 |
| Less affected | 37 | 58 | 16 | 32 |
| Affected | 41 | 19 | 29 | 29 |
| More affected | 16 | 11 | 48 | 34 |

Table 3.1. Influence of COVID-19 in the Danish sectors in April 2020. (Based on Danmarks Statistik (2020a))

As shown in table 3.2 on the next page, 48 % of the companies in the building sector have had a revenue drop of 0-25%, whereas 11% of the companies have had a drop by 25-50% and 37% of

the companies have been not affected so far.

"How do you think the Corona situation has affected the company's revenue in the past month?" (4)

| Unit/ percentage | Industry | Construction | Service | Retail |
|------------------|----------|--------------|---------|--------|
| Fallen 0-25% | 38 | 48 | 32 | 20 |
| Fallen 25%-50% | 6 | 11 | 13 | 13 |
| Fallen 50%-75% | 4 | 3 | 4 | 5 |
| Fallen 75%-100% | 1 | 1 | 14 | 15 |
| Not affected | 40 | 37 | 35 | 11 |
| Increased | 12 | 0 | 2 | 35 |

Table 3.2. Decrease in revenue perceived in the main Danish sectors (Based on Danmarks Statistik (2020a))

As observed in table 3.3, it is perceived that the Danish construction industry is at no risk of collapsing due to the outbreak. At least, when the study was performed by Danmarks Statistik during the month of April 2020.

"With the current knowledge, what is the risk that your company must be closed down the next three months due to the Coronavirus? " (5)

| Unit: weighted percentages | Industry | Construction | Service | Retail |
|----------------------------|----------|--------------|---------|--------|
| No risk | 79 | 70 | 79 | 67 |
| Minor risk | 16 | 23 | 15 | 29 |
| Medium risk | 3 | 6 | 5 | 4 |
| Major risk | 2 | 1 | 1 | 0 |

Table 3.3. Risk of the company has a permanent shutdown in the first 3 months of the COVID-19 outbreak in Denmark, main segments. (Based on Danmarks Statistik (2020a))

Globally, the number of confirmed cases and deaths as of this thesis writing (24 April 2020) has reached respectively, 2.733.591 and 191.185 in 210 countries. Meanwhile in Denmark, the number of confirmed cases and deaths are respectively, 8.210 and 394, reported on 24 April 2020.(Worldometers, 2020a) Unfortunately, these numbers outgrow very fast every single day. In the figure 3.4 on the next page is shown the huge spike of the confirmed cases of the infection in Denmark since the first case on 27 February up to 22 April 2020.

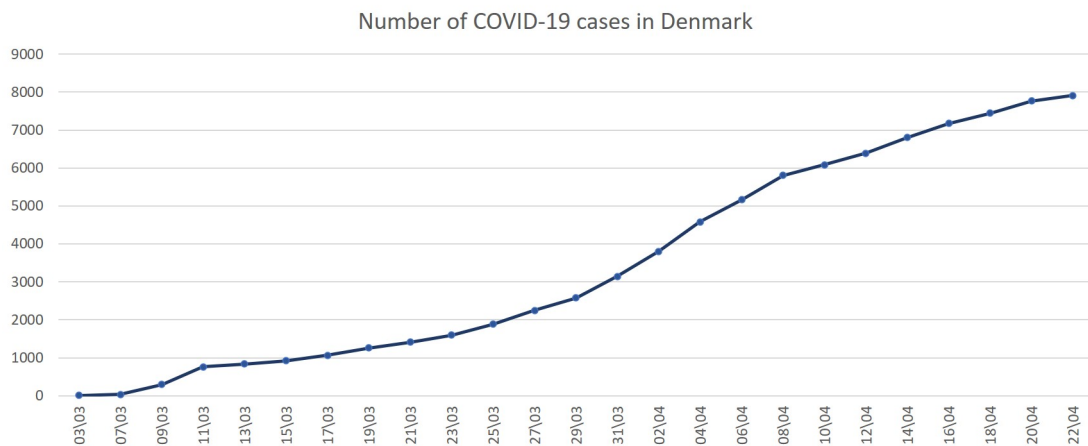


Figure 3.4. Cumulative number of COVID-19 Cases in Denmark since February 2020 (as of 22 April 2020) (Based on (Statista, 2020))

As previously mentioned in 1.4 on page 3, during the first quarter of 2020, there was a boom in the number of construction workers employed on the Danish building sites in comparison to past years on the same period. However, due to the sudden outbreak of the infection worldwide, where the novel COVID-19 has caused severe economic strain across the globe, doubts have arisen about a transient unemployment rate on the Danish building sector. Time will tell whether or not the upcoming crisis will affect hard the building industry. It depends heavily on how long this novel COVID-19 will last.

It could take quite a bit before the pandemic is over or when the governments and the medical community will eventually be able to successfully mitigate the transmission of the virus.

It is worth to mention that at the current date, there are no specific antiviral treatment for humans or any vaccine against COVID-19. (Rothan and Byrareddy, 2020) Furthermore, a vaccine for COVID-19 could be about 18 months away. (Reuters, 2020)

As time passes by, the rules and measures imposed onto the society during the lockdown have been relaxed little by little in Denmark. However, the numbers of worldwide infected people are 6.891.213, the numbers of deaths around the globe are 399.718. In Denmark, currently the number of infected persons are 11.924, and the number of deaths are 587. (as in 7 June 2020) (Worldometers, 2020b)

3.2 Defining key terminology in H&S in the building industry

After reviewing the situation of H&S in the construction industry worldwide, it is beneficial to define the key terms used in the realm of health and safety.

Health is the general condition of an individual in his/her mind, body and soul, generally speaking, it means the absence of any sort of illness, injury or pain. The World Health Organization (WHO), (World Health Organization et al., 2006) defined health in 1946 and ratified its meaning many times as:

"A state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity". (6)

In this research, therefore the terminology *health* suggests an individual being free from any illness, injury or any pain caused or related to any construction activity.

Safety is defined by Hughes and Ferrett (2007) as:

"The protection of people from physical injury". (7)

In this paper, safety is perceived as the state where a construction worker is protected from danger, harm, and injury during construction activities taking place on the construction site.

Health and safety are expressions normally used together in the construction industry, as a matter to define measures of protecting the construction staff from injuries and work related illnesses triggered by activities and conditions associated to the construction work on the building sites. (Health and Safety Executive, 2003) This terminology is adopted as definition of H&S in this study.

Accident and injury are referred to two distinct events that are mutually interconnected as the cause and the effect. (Anderson, 1999) Thus, the words *accident* is hereby expressed in accordance with the definition given by Hughes and Ferrett (2007) as:

"Any unplanned event that results in injury or ill-health of people, or damage or loss to property, plant, material or the environment or a loss of a business opportunity" (8)

However, the definitions of *accident* and *injury* are adopted from the first World Conference on Accident and Injury Prevention, Stockholm in 1989 (WHO 1989) which is, *an "accident" is an unintentional event that results or could result in an injury, whereas "injury" is a collective term for health outcomes from intentional or unintentional traumatic events.* (Andersson and Menckel, 1995) The term *accident* in this thesis, is defined as an event that causes physical injury or harm to a person's body.

Hazard is, paraphrasing Hughes and Ferrett (2007):

"The potential of a substance, activity or process to cause harm." (9)

In other words, a hazard is often associated with an activity or process that, if left uncontrolled or unattended, can result in an injury or illness to someone. In this research, a hazard is defined as anything that can potentially cause harm to the crew on construction sites.

Regarding risk, the literature on risk is very vast, therefore an attempt to review these literature studies would be difficult within the scope of this research, thus risk is considered as an important subject area especially under construction management segment. In terms of H&S, several definitions have also been used for risk. Therefore, it is essential to provide a good definition in this study.

One of these definitions include the following from [British Standard Institute \(2008\)](#), which says that *risk* is:

"The combination of the likelihood of an occurrence of a hazardous event or exposure(s) and the severity of injury or ill health that can be caused by the event or exposure(s)." (10)

Risk is also defined by [Hughes and Ferrett \(2007\)](#) as:

"The likelihood of a substance, activity or process to cause harm." (11)

Moreover in the context of this thesis, the meaning of risk is the one given by the quotation from [British Standard Institute \(2008\)](#).

3.3 Accidents and ill related problems in the construction industry

The construction industry is known for its reputation of being one of the worst industries in terms of onsite H&S. Nevertheless, the inadequate H&S performance on building sites has triggered various studies with the intention of identifying the causes of construction accidents, so that appropriate reduction measures could be implemented. ([Suraji, 2001](#)), ([Haslam et al., 2005](#)), ([Whittington et al., 1992](#)).

Many researchers categorized H&S hazards in either physical injury or ill-health hazards, as stated by [Murie \(2007\)](#), [Davies and Tomasin \(1996\)](#) and [Health and Safety Executive \(1998\)](#).

The physical injury hazard includes death whereas the ill-health hazard can cause illness or death after a period of time has lapsed. ([Murie, 2007](#))

Like the safety circumstances, the health situation in the building industry is also alarming. Health related issues such as stress, depression, anxiety, and arm vibration syndrome and respiratory diseases, musculoskeletal disorders, dermatitis, cement burns, hearing loss are not unusual in the building industry. ([Health & Safety Executive, 2019](#))

In Denmark, according to [Arbejdstilsynet \(2019\)](#), the number of reported accidents increased from 4.817 in 2015 to 5.423 in 2018, in the construction segment, as shown in the figure 3.5 on the next page.

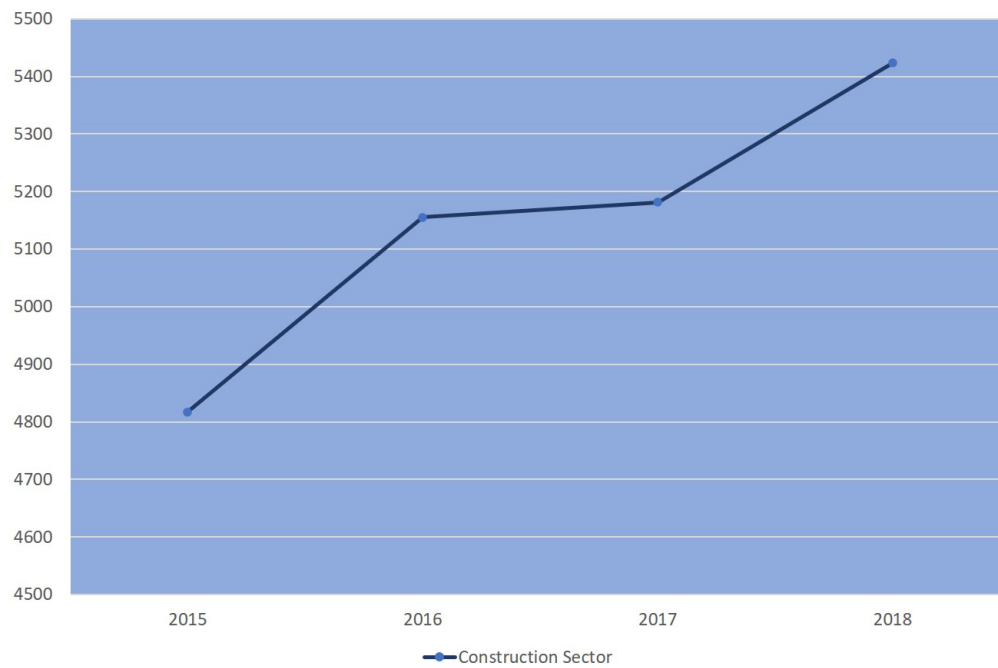


Figure 3.5. Accidents in the Danish Building Sector (Based on (Arbejdstilsynet, 2019))

Based in the report of work-related accidents of the construction sector provided by Arbejdstilsynet (2019), the majority of the construction workers that suffered one work-related accident had 1 to 3 days of sick pay in Denmark between the years 2015-2018. It was reported a total of 5 deaths associated with the construction work for the years 2015 and 2017 in Denmark, whereas there is no reported death for the years 2016 and 2018. In the table 3.4, is shown the amount of sick pay that the workers were entitled while recovering from the work-related injuries.

| Number of days/Year | 2015 | 2016 | 2017 | 2018 |
|--|-------------|-------------|-------------|-------------|
| Disability 1 to 3 days | 1596 | 1604 | 1683 | 1659 |
| Disability 4 to 6 days | 799 | 856 | 831 | 895 |
| Disability 7 to 13 days | 776 | 839 | 802 | 853 |
| Disability 14 to 20 days | 492 | 542 | 498 | 442 |
| Disability 21 days to 1 month | 242 | 312 | 254 | 232 |
| Disability 1 to 3 months | 630 | 650 | 648 | 682 |
| Disability 3 to 6 months | 191 | 191 | 167 | 149 |
| Permanent disability or more than 6 months | 64 | 66 | 52 | 57 |
| Fatal accidents | 5 | | 5 | |
| Disability not informed | 9 | 67 | 227 | 423 |
| Unknown | | 7 | | |
| Total | 4805 | 5137 | 5167 | 5394 |

Table 3.4. Injuries and illnesses in the building sector in Denmark, years 2015-2018, based on (Arbejdstilsynet, 2019).

3.3.1 Types of accidents and ill-health related issues in the building industry

Although the accident data collection tends to concentrate on fatal accidents, it is paramount to be recognised that way more employees in the construction industry die from the chronic effects of ill-health related issues caused by or made worse at workplace. (Donaghy, 2009)

The most common hazards on construction sites regardless of the physical injury or ill-health issues are identified as the following:

- Working at Height
- Electricity
- Noise
- Vibration
- Asbestos
- Dust
- Equipment, tools and machinery
- Manual handling
- Slips and trips
- Mental effects, traumatic events, aggression and bullying

These usual hazards found on the building sites are further explained one by one.

Working at Height

When a job at altitude is planned, some necessary measures should be taken in order to do the job properly. This includes the technical aids that should be used regarding H&S. Among other things guidelines or setup guides, risks for the use of aids, transport and work routes, proper engagement of the people involved, who is certified to work at heights, are the things that should be arranged in advance. (Brancharbejdsmiljørådet for Bygge & Anlæg, 2016) The risk of falling from heights, is higher to window cleaners, painters, masons, decorators and those who work without proper training, protective equipment or planning. (Murie, 2007)

A report made by Health and Safety Executive (2014) found that approximately 45% of the fatalities are mainly caused by falls from heights in the UK.

Electricity

Sometimes it is necessary to work below power lines. Any work involving electrical power lines and electrically powered equipment can result in serious or fatal injuries. Therefore, some of the most common operations that can lead to contact with overhead power lines are: Operating cranes or other lifting equipment, raising the body or inclined container of tipper lorries, operating excavators and other earth-moving equipment, handling long items such as scaffolding, metal roof sheets, ladders, using mobile elevated working platforms. In case of excavations elevated posts with high visibility can prevent accidents. It is important to eliminate the risks of electrocution on the site by using machinery with lower voltage or battery powered equipment. By conducting visual inspections to the electric machinery the site manager has to make sure: that the wires are properly insulated, the plugs are in good condition and the machine works properly. (International Labour Organisation, 2015) In the UK, for instance, 2% of all the work-related fatalities are caused by electric shocks. (Hughes and Ferrett, 2011)

Noise

Noise can lead to permanently impaired hearing or even damage to the inner ear. Hearing damage accumulates the first couple of years of exposure but it is recognised when the worker

gets older. Deceases such as "tinnitus" and hyperacusis are the most common. Therefore, the limit of exposure to noise is 85dB on average for a time frame of 8 hours. Among other things, noise can also lead to elevated blood pressure or pulse. As a result the employer has to make sure that the above limit is being kept by making arrangements for the shifts or if this is not possible provide earplugs.([Brancharbejdsmiljørådet for Bygge & Anlæg, 2016](#))

Vibration

The amount of vibration a worker can be exposed is limited as well. The vibration load should not exceed the 2,5m/s over the period of 8 hours while the time frame should be further reduced if the vibration speed is greater. If possible methods that exclude vibration should be used like diamond cutting, blasting, or water jet cutting. Another technical aid that can be used is vibration dumping gloves but these are only suitable for high frequency vibrations. Exposure to vibration can lead to "white fingers" numbness and needle sensation. Extensive exposure to vibration can even lead to arthritis or permanent loss of sensation.([Brancharbejdsmiljørådet for Bygge & Anlæg, 2016](#))

Asbestos

Asbestos was used as an insulating material and also for panelling until 1986. This material was found to cause cancer of the throat, lungs and pleura. The use of it is prohibited and the only activity involved with asbestos is the demolishing repairing and maintenance. Workers who have to demolish asbestos must have a special training. Employers who undertake such activities should make sure that the workers should not reach the limit of airborne asbestos and maintain a log with the exposure of each worker to asbestos, while keeping that log for 40 years. Information such the nature of the work, the duration of the exposure and the working site address should also be included.([Brancharbejdsmiljørådet for Bygge & Anlæg, 2016](#))

Dust

A lot of the activities in the building sector are producing dust. It is necessary when cleaning to produce as little dust as possible by vacuuming or washing. When fine particles of dust are inhaled they end up in the smaller parts of the lungs. As a result, the mucous membrane of the lungs gets irritated while chronic exposure can even lead to lung cancer. Such examples of fine dust includes quartz dust, wood dust and, dust from angle grinders.([Brancharbejdsmiljørådet for Bygge & Anlæg, 2016](#)) Yet, if the dust is harmful, there is a chance that the construction workers will get an adverse health problem, which may range from some minor impairment to irreversible illnesses and life-threatening situations. ([Hughes and Ferrett, 2011](#))

Equipment, tools, transport and machinery

When a new machine is purchased some things has to be assessed: the noise limits, the daily cleaning and maintenance of the machine, what H&S risk the machine involves, where and how will it be used by. Machines should be fitted with the necessary protective equipment, be user-friendly, and as quiet as possible. A manual with information about the function, warnings, setup, maintenance should be included. The machines should be inspected to ensure safety. Faulty machinery or in proper use can cause accidents or even fatalities in the industry.([Brancharbejdsmiljørådet for Bygge & Anlæg, 2016](#))

Manual handling

Manual handling is defined as the movement of any load by human effort alone without help of machinery. ([Hughes and Ferrett, 2011](#)) Usually the used labor on the construction site is

manual. Manual labor can result in chronic pains, injuries even deaths if not properly practiced. Some of the manual labor include activities such as *heavy lifting*, *monotonous repetitive work*, *poor working conditions* and *heavy work*. Using technical aids for these purposes can ease the workload on the worker and furthermore reduce the risk of minor or severe injuries. There are certain recommendations on practices about lifting, carrying, pulling and pushing, working postures and the duration of these activities in (Branchearbejdsmiljørådet for Bygge & Anlæg, 2016)

Smallwood and Ehrlich (2008) found in their study that in the construction sector, 25% of injuries are back injuries.

Slips and trips

Slips and trips are the most common workplace hazards and are estimated to be accounting for over a third of all major onsite injuries. (Hughes and Ferrett, 2011)

Mental effects, traumatic events, aggression and bullying

The mental working environment is different in the construction sector than other industries. This industry involves many trades and the requests to meet the time frames are demanding. Working relations may also contribute to clashes between the trades because in this sector the relations are not limited to employer and employee but in many actors like project designers, suppliers, developers. The above factors can produce mental stresses at work which can lead to sick leaves, mental burnout, lack of job satisfaction, conflicts, or employees leaving the company. The workers of construction site might also witness an accident themselves. This can create trauma to some workers. Moreover, as this applies to all working environments, bullying and sexual harassment is another problem that occurs and the management has to take measures for its prevention. (Branchearbejdsmiljørådet for Bygge & Anlæg, 2016) Aggression, violence and bullying can contribute indeed to other illnesses such as stress. (Hughes and Ferrett, 2011)

As observed in table 3.5, the type of hazards are linked to the type of work occupation on the construction sites.

| | Occupations | Hazards |
|---|--------------------|--|
| 1 | Brick masons | Awkward postures, heavy loads, exposure to cement |
| 2 | Hard tile setters | Vapour from bonding agents, dermatitis, awkward postures |
| 3 | Carpenters | Wood dust, heavy loads, repetitive motion |
| 4 | Drywall installers | Plaster dust, walking on stilts, heavy loads, awkward postures |
| 5 | Electricians | Heavy metals in solder fumes, awkward postures, heavy loads, asbestos dust |
| 6 | Painters | Solvent vapours, toxic metals in pigments, paint additives |
| 7 | Plasterers | Dermatitis, awkward postures |
| 8 | Plumbers | Lead fumes and particles, welding fumes |
| 9 | Pipefitters | Lead fumes and particles, welding fumes, asbestos dust |

Table 3.5. Main hazards to which skilled construction workers are exposed in selected occupations, based on (International Labour Organization, 2015).

From the table 3.5, it is clear that these listed professions are exposed to many work-related hazards every day on the building sites.

3.3.2 Causes of accidents in the building industry

Studies about the causes of accidents in construction industry revealed that is of great importance to emphasise on the underlying casual factors which can be related to the upstream procurement processes of the construction project. This measure can result in improvements in the onsite H&S. (Haslam et al., 2005), (Brace et al., 2009).

During the pre-construction phase, there is a good chance of influencing H&S on the construction project by focusing into the underlying casual factors. Because at this stage, the project offers are presented so, there is the opportunity that the project participants can influence onsite safety. (Brabazon et al., 2000), (Szymberski, 1997). Moreover, underlying causal factors of fatal accidents are often bonded to either design, leadership and planning. Therefore, it is vital that sufficient consideration is taken during the design and planning stages since onsite incidents can be prevented by better appreciation and reduction or elimination of hazards during design phase. (Donaghy, 2009)

In order to grasp the main sources of incidents and subsequent followed injuries that occur mostly on the construction sites, researchers have attempted to develop theories of why these accidents most frequently happen. On one hand, the onsite accidents are seen as originating from either a technical failure or human error. (Murie, 2007), (Chi et al., 2005)

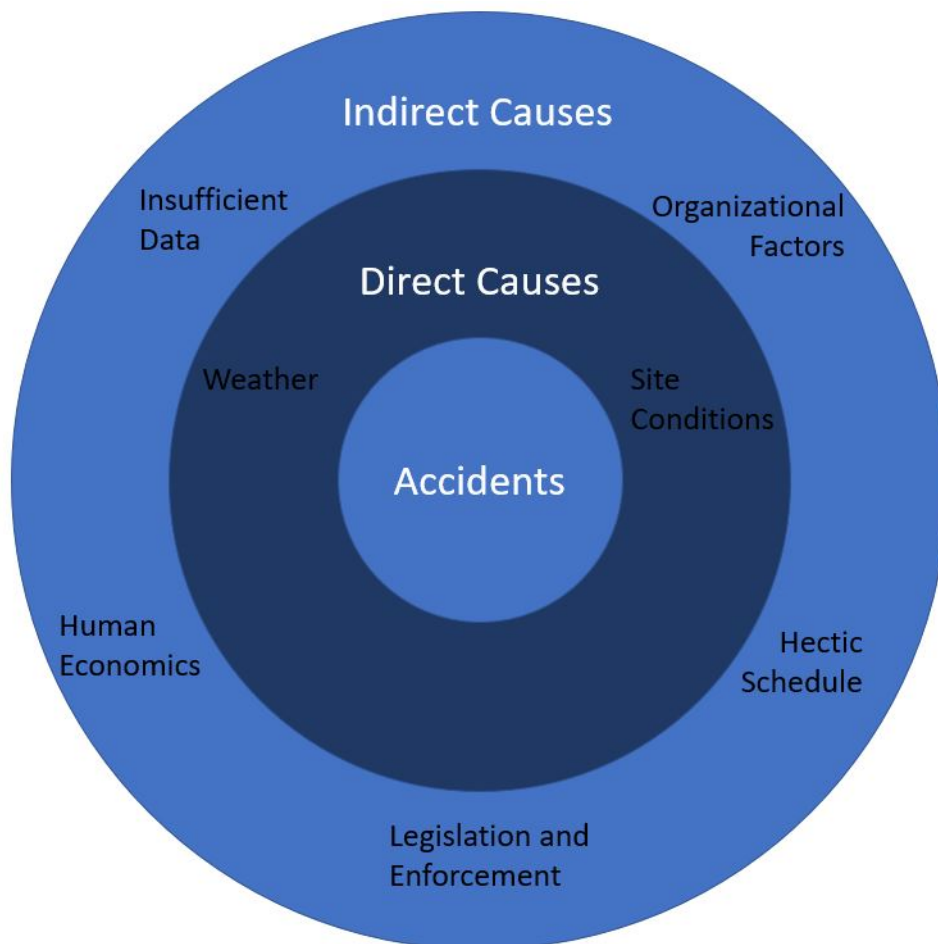


Figure 3.6. Causes of construction accidents (Based on (Li and Poon, 2013))

As mentioned by [Li and Poon \(2013\)](#), the causes of the construction accidents can be divided into 2 main categories' types: direct and indirect causes, as shown in figure 3.6 on the preceding page. In the direct category are the causes that have an ultimate and therefore immediate effect on the construction staff's safety condition like for instance, the weather and site conditions. As for the indirect category, are the distant causes for the accidents, such as human, and organisational factors.

The **direct causes** are described as the *weather* and *site conditions*. The *weather* is a factor that is difficult to foresee and therefore it can substantially impact the planning and the outcome of the construction project. The *site conditions*, are related to one important safety element. In this category, good site layout is definitely *conditio sine qua non* for ensuring a proper and safe working environment. In addition to that, structural failures of a structure under construction or the use of non-standards short term manners for supporting a structure onsite. The **indirect causes** are related to human involvement (i.e. fatigue, insufficient safety training and education, errors, migrant workers) hectic schedule, economics, organisational causes (i.e. subcontracting, temporary workforce, size of the companies, separation of professions) legislation and enforcement, as well insufficient data. ([Li and Poon, 2013](#))

As highlighted in 1.2 on page 2, in accordance to [Pandit et al. \(2019\)](#), safety communication among construction staff is seen as a crucial tool to reach a satisfactory safety management. In fact, poor safety communication is still an reoccurring problem on the construction sites that leads to injuries. ([Pandit et al., 2019](#))

In fact, a research done by [Egawa and Nakamura \(2000\)](#) identified communication errors among construction crew the reason of an extensive number of accidents in Japan.

According to ILO, 1 out of 6 accidents and 25 out of 40 fatal accidents that occurred on building sites in 2013, occurred either because of negligence or carelessness, which means due to not proper communication and labour related problems. ([Ramasamy et al., 2016](#)).

3.3.3 Cost of injuries and illnesses in the industry

Based on an estimation given by [Pearce \(2003\)](#), the annual costs of work-related injuries and deaths in the construction industry are over £2 billion on this industry.

These costs of injuries and illnesses are considered as either direct costs and indirect costs in accordance to [Hughes and Ferrett \(2007\)](#), some of theses costs are estimated in monetary terms whereas others are estimated in the suffering, pain and other psychological damages brought up to the workers, families and therefore, it is somehow difficult to give a monetarily estimation of these costs.

There are shown in the table 3.6, examples of direct and indirect costs related to injuries and illnesses in the construction industry.

| Costs of injuries and illnesses | |
|--|--|
| Direct costs | Indirect costs |
| Sick pay | First aid provision and training |
| Medical expenses | Accident investigation |
| Fines resulting from prosecution by the enforcement authority | Implementation of corrective measures |
| Claims on employers and public liability insurance | Production delays |
| Production and/or general business loss | Repairs of damaged equipment and property |
| Legal representation relating to prosecution | Lost time for other employees |
| Any compensation not covered by the insurance policy | Cumulative business loss |
| Pain, suffering and psychological impact caused to victims, family | The economic impact on victim's family |
| Increases in insurance premiums | Lowering of employee morale possibly leading to reduced productivity |
| Compensation claim | The recruitment and training of replacement staff |
| Loss of enjoyment of life | Loss of goodwill and a poor corporate image |

Table 3.6. Costs of injuries and illnesses based on (OSHA, 2020),(Pearce, 2003), (Kapp et al., 2003) (Hughes and Ferrett, 2007), (Ikpe, 2009), (Mthalane et al., 2008), (Saram and Tang, 2005).

These costs related to the injuries and illnesses harm the reputation of the construction industry (Wang et al., 2006) , as indicated by the indirect costs shown in table 3.6 which obviously indicate the need for further H&S improvement on building sites.

In Denmark, a report made by Bygge-, Anlægs- og Trækartellet or BAT-kartellet (2011) , highlighted the notion of what it takes for 6 specific work related accidents. *The average cost of the one accident was, alone, DKK 35.460. (BAT-kartellet, 2011)*

As shown in table 3.7, the turnover of a small company for being able to cover work related expenses of DKK 35.460 is DKK 738.750, whereas for a large company, is around DKK 2.364.000.

| How much turnover a company must have in order to be able to pay for a work accident of 35.460 kr? | |
|--|---------------|
| Small companies | 738.750 kr. |
| Medium companies | 1.226.400 kr. |
| Large companies | 2.364.000 kr. |

Table 3.7. The necessary turnover for a company in case of a work related accident of DKK 35.460, based on (BAT-kartellet, 2011)

From this report made by BAT-kartellet (2011), the following citation is extracted:

Med 4.522 anmeldte ulykker i bygge- og anlægs- branchen i 2010 og en gennemsnitlig meromsætning pr. ulykke på 2.085.900 kr. når vi frem til, at bygge- og anlægsbranchen skal omsætte for 9,4 mia. kr. hvert år for at dække udgifterne til de arbejdsulykker, der anmeldes til Arbejdstilsynet. (12)

But this is surprisingly alarming, due to the fact that in order for a company be able to cover all the costs of a work related accident of DKK 35.460, this company in the construction industry must have a turnover of DKK 2.085.900. (BAT-kartellet, 2011)

The profit rate in the building industry has increased from 1,7 % in 2010 to 4,9 % in 2012, however, many companies still operate with small profit rates. (Licitationen, 2015) Therefore, one may conclude that the costs of the accidents in the construction industry are recognized as a burden hard to bear.

3.4 H&S challenges of the construction industry

The construction industry by its characteristics like for instance, the segregation of the industry, the increase employment of migrant workers and the small integration in the supply chain, causes obstacles to enhancing H&S. (Brabazon et al., 2000), (Brace et al., 2009)

3.4.1 Segregation in the construction industry

The building industry is known as a fragmented and dynamic sector with a project based nature. This nature makes that its various stakeholders operate in frequently changing sets of professional relationships with contractual purposes. This segregation nature is based in a set of conflicts and lack of mutual respect and trust. (Dainty et al., 2007)

Abadi (2005) appointed the definition of the segregation, in the context of the building industry, as:

"the division resulting from the increasing number of both professions (i.e. architect, engineer) and organizations involved in all processes of a building project. This has been caused by the growing demand for differentiation and specialization as building projects increase in both size and complexity." (13)

Nevertheless, it is not only due to the different professions working in the same project as mentioned by Dainty et al. (2007) that this fragmentation occurs in the building sector, but also due to the fact that the traditional procurement practice (design-bid-build) is the most common procurement in the construction industry, and it splits the design from the construction process. (Nawi et al., 2014)

Paraphrasing Nawi et al. (2014), "in general, fragmentation within the construction industry arises from two areas within the traditional construction process; the construction work process where the most significant division is in the separation of the design and construction phase, and the construction structure itself."

The fragmentation in the building industry, combined with the diversification of project sizes and the temporary nature of these projects, behaves as hindrance to the management of H&S. (Brabazon et al., 2000)

3.4.2 Migrant workers

Recently, the Danish building industry has experienced an increase in foreign workers, this group of workers accounted for 16% of the construction workforce in Denmark in 2019. (TV2, 2019)

Thus, the migrant workers experience challenges in regards with the limited knowledge of H&S in the workplace, the ability to communicate with the rest of the crew and accessibility to appropriate safety training due to the language barriers. (Dainty et al., 2007)

3.4.3 Supply chain in the building industry

Supply chain is essential for the success of a construction project. However, little integration in the construction industry is observed where the supply chain representatives decide about important matters such as the design which has tremendous impact onto onsite safety. (Hare et al., 2006), (Baiden, 2006)

Usually H&S risks are highlighted on the building sites. In order to mitigate the overall risks manifested on the construction sites, effective risk control measures for the design, planning and supply chain recruitment can be proposed on an earlier stage as suggested by Szymberski (1997).

3.5 H&S rules and regulations

In Denmark what dictates the rules of H&S is the Working Environment Act (Act no. 1072 September 2010). The purpose of this act is to create :

1. a healthy and safe working environment which keeps up with the technical and social development of society
2. a base for for the companies to have the ability to solve H&S issues themselves with the involvement of their employers and workers under the guidance of the Working Environment Authority.

General Duties

According to Arbejdstilsynet (2010) (Working Environment Act) it is the employer's duty to ensure safe and healthy working conditions with special references to:

- performance of the work.
- design and fitting out of the work site
- technical equipment
- substances and materials

The employer has to prepare a written workplace assessment. In it the following should be included: the H&S conditions of the workplace, nature of the work, the methods and processes, and the size of the organisation. The workplace assessment should remain in the company and it should be available to all the company's member as well as to the Working Environment Authority which inspects these assessment. This assessment should be revised every three years the

least while, the principles must comply with the H&S legislation. More specific it should include among others: Identification and mapping of the H&S condition of the company, description and assessment of the H&S issues of the company, priorities and a plan of action resolving the issues reported previously, and guidelines for how to follow the action plan. The employer should inform the workers for the risk of accident and he should supervise effectively the work performance. (Arbejdstilsynet, 2010)

3.5.1 Risk Assessments

As stated by British Standard Institute (2008), **risk assessment** is the:

"process of evaluating the risk arising from a hazard(s), taking into account the adequacy of any existing controls, and deciding whether or not the risk is acceptable." (14)

Risk assessments have two basic forms. The first is a quantitative RA that tries to measure the risk by relating the probability of the risk happening to the possible severity of the outcome giving a numerical grade. But the most common form of RAs are the qualitative assessments. These assessments are based purely on personal judgment and they are given a low, medium, high risk grade. The grading usually in the qualitative RAs is defining the time frame in which further action is to be taken and that makes this type of RAs more satisfactory. There are also some RAs called "generic". These RAs are the ones that are produced by trade unions or specialist bodies and they can cover similar activities in a specific industry. (Hughes and Ferrett, 2007)

The figure 3.7 shows the qualitative risk assessment matrix based on Bowden et al. (2002), where different levels of risks are identified, like for instance negligible injury as level 1, minor injury as level 2, moderate injury as level 3, major injury as level 4, or fatality as level 5. Likewise, likelihoods can be determined as: very likely at level A, likely at level B, possible at level C, unlikely at level D, or rare at level E.

| Likelihood | | Consequences | | | | | Risk rating |
|------------|-------------|---------------------|----------------|----------|----------------|----------|---|
| | | 1 | 2 | 3 | 4 | 5 | |
| | | Negligible Injuries | Minor Injuries | Moderate | Major Injuries | Fatality | |
| A | Very likely | A1 | A2 | A3 | A4 | A5 | <div>Extreme</div> <div>High</div> <div>Moderate</div> <div>Low</div> |
| B | Likely | B1 | B2 | B3 | B4 | B5 | |
| C | Possible | C1 | C2 | C3 | C4 | C5 | |
| D | Unlikely | D1 | D2 | D3 | D4 | D5 | |
| E | Rare | E1 | E2 | E3 | E4 | E5 | |

Figure 3.7. Qualitative risk assessment matrix (Based on (Bowden et al., 2002))

Thus, there are 25 potential risk combinations where the risk outcomes are divided in further risk levels, which are extreme, high, moderate or low rating levels as shown in figure 3.7. From this rating, the extreme level should be tackled first, due to the fatality risk, whereas the low rating shows that for instance, negligible injury can be handled with first aid on the building site. However, it is important to underline that this qualitative approach has limitations as well, therefore the effects of risk reduction measures within the risk matrix are difficult to incorporate into the real world, and this method is not ideal to use in order to assess cumulative hazards, especially on building sites, where a large number of hazards can occur simultaneously. (Bowden et al., 2002)

The assessment of risk is performed in order to provide risk control decisions, as well the implementation of the assessment which is monitored and reviewed to secure that any further risk is controlled and stays within tolerable boundaries. (Lingard and Rowlinson, 2005)

Quantitative risk assessment employs numerical values in order to evaluate the consequences and the likelihood of a given event. The matrix for evaluation of quantitative risk uses low, medium and high ranks, and describes the risk as the rate of injury or even death. (Marhavidas and Koulouriotis, 2008), (Ayyub, 2003),

The risk is then assessed by analysing potential consequences of an incident within both the exposure and the probability factors. (Marhavidas and Koulouriotis, 2008) Meanwhile, a risk matrix is made in order to showcase the risk likewise in the case of the qualitative approach. However, only numbers are shown in order to assess and estimate the probability and the consequences. See figure 3.8.

| | Hazard Probability Ratings | | | | | | | | | |
|----------------------------------|----------------------------|----|----|----|----|----|--|--|--------------------------|-------|
| Severity of Consequences Ratings | 1 | 2 | 3 | 4 | 5 | 6 | | | | |
| 1 | 1 | 2 | 3 | 4 | 5 | 6 | | | | |
| 2 | 2 | 4 | 6 | 8 | 10 | 12 | | | Unacceptable | 18-36 |
| 3 | 3 | 6 | 9 | 12 | 15 | 18 | | | Undesirable | 10-16 |
| 4 | 4 | 8 | 12 | 16 | 20 | 24 | | | Acceptable with controls | 5-9 |
| 5 | 5 | 10 | 16 | 20 | 25 | 30 | | | Acceptable | 1-4 |
| 6 | 6 | 12 | 20 | 24 | 30 | 36 | | | | |

Figure 3.8. Quantitative risk assessment matrix (Based on (Marhavidas and Koulouriotis, 2008))

In the figure 3.8 is indicated the matrix for quantitative risk estimation, where 6 levels of risk are defined. It indicates that when the number increases in both the severity and probability, the risk is higher for that event. Likewise, the figure shows the rating where the higher numbers matches with the higher risk which therefore, it turns the event into "unacceptable".

The purpose of risk evaluations is to decide whether or not a risk is acceptable. (Lingard and Rowlinson, 2005), (Hughes and Ferrett, 2007) If the risk is regarded as acceptable as shown in figures 3.8 and 3.7 on page 31, it is sufficient to just control the risk instead of decreasing it. However, if the risk is regarded as unacceptable, different risk mitigation measures must be taken.

All companies have to prepare written Risk Assessments. The process of carrying out these documents involves also the employees. As a result RAs are a tool that has to do with the working environment and they can help a company to identify H&S issues that may arise. Therefore, RAs can benefit a company in various ways such as:(WEA, 2020)

- Reducing the cost of occupational accidents.
- Reducing payed sick leave.
- Reducing frictions among employees.
- Increasing job satisfaction, motivation and productivity.

Nevertheless, after the assessment of the risks, the findings from these risk assessments are used for undertaking risk controls. (Lingard and Rowlinson, 2005)

Risk control is defined by British Standard Institute (2008) as:

"selection and application of suitable measures to reduce risk." (15)

3.5.2 Risk Assessments in Denmark

According to WEA (2020) a RA contains five elements that a company must include. The company must survey the working environment and detect any H&S issues. After, these issues must be described and evaluated proposing a resolution while assessing working environment circumstances that can potentially increase the risk of payed sick leave. Subsequently, a plan of action should be drafted that describes, among other things, when, how and by whom any hazards should be resolved. Lastly, the plan describes how the company will follow that plan and how is responsible for the implication of it. By law the WEA doesn't have the authority to approve a company's RAs but it has to check if they are implemented. (WEA, 2020)

3.5.3 Working Environment Organisations within Enterprises

H&S cooperation is promoted in enterprises in Denmark. The formation of these organisations ensures good working conditions and safety. By doing that the employees can have a long lasting working life and also maintain a life with good quality. All enterprises employ ten or more people must have a WEO. The team can be consisted by employees and managers. (Branchearbejdsmiljørådet for Bygge & Anlæg, 2016)

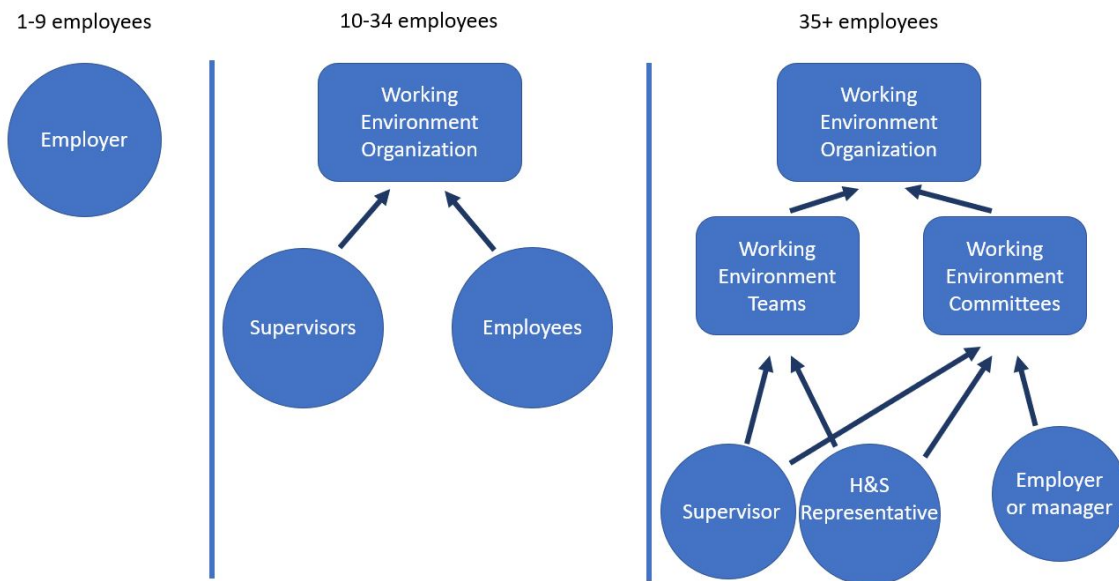


Figure 3.9. Compositions of Working Environment Organisations (Based on(Branchearbejdsmiljørådet for Bygge & Anlæg, 2016))

Composition

As seen on figure 3.9 the number of members in Working Environment Organizations is dependant on the total amount of the employees of the corporation. In addition, every WEO must have at least the same number of working environment representatives and supervisors(business managers). The supervisors must have the necessary expertise about the production and their work areas. Moreover, the working environment representatives should be available for the rest of the employees and make sure that they can be contacted during working hours. For construction sites specifically, the number of employees is counted per construction site, the number of employees in the home enterprise is usually not included.(Branchearbejdsmiljørådet for Bygge & Anlæg, 2016)

Companies with **one to nine workers** do not have the obligation to compose a WEO. Instead the employer has to take initiatives to ensure that H&S cooperation is taking place among the staff. The necessary information about H&S has to come from the employer while he has to make sure that all the employees has to participate in planing and introducing new technology, the consequences for H&S about the equipment and of course the Personal Protective Equipment. However in construction sites the limitations are more strict, if the number of employees is above 5 for more than 14 days then the employer has to create a WEO.(Branchearbejdsmiljørådet for Bygge & Anlæg, 2016)

When a company employs from **10 to 34 workers** it has to assemble a WEO. This specific WEO has to consist of supervisors and selected working environment representatives while the business manager will be the foreman of this team. Also this formation has to carry out both strategic and general task while it has to come along with solutions for the day to day issues of H&S.(Branchearbejdsmiljørådet for Bygge & Anlæg, 2016)

For companies with **more than 35 people** as staff, the director has to assemble a WEO that will consist of:

- One or additional working environment teams.
- One or additional working environment committees.

A working environment team has two members, one supervisor and one working environment representative. A Working environment committee consist of members of the working environment teams with the employer or business manager as a foreman. ([Branchearbejdsmiljørådet for Bygge & Anlæg, 2016](#))

3.6 Safety management

As stated by [Kennedy and Kirwan \(1998\)](#), safety management should be considered as a management system that is documented and formalised in matters of controlling against any kind of risks or harms.

In order to guide the safety management, a new international standard was published in 2018, known as ISO 45001 from 2018, which provides a framework, despite of size and geographical location of the building site, to manage and continuously implement of H&S. ([International Organization for Standardization, 2018](#))

3.6.1 ISO 45001:2018

The International Organisation for Standardization in 2018 published ISO 45001:2018 which provides a framework for improving Occupational Health and Safety (OH&S) standards. This framework can be applied regardless the size or activities of the organisation, geographical location. By encouraging employees participation, the organisation can integrate OH&S in the business processes which can lead to decrease in accidents and long or short term ill health effects. ISO 45001 can develop a positive safety culture which consequently, leads to employees' well-being. The standard's requirements can help significantly an organisation to enhance the culture with challenge and improvement. ISO 45001:2018 took its form from the initial version of (Occupational Health and Safety Assessment Series) OHSAS 18001:2007. ([International Organization for Standardization, 2018](#))

Plan Do Check Act cycle

ISO 45001 follows a four stage cycle: Plan Do Check Act (PDCA).The scope of OH&S system can be seen in figure 3.10 on the following page.

According to [International Organization for Standardization \(2018\)](#) the PDCA is described as follows and can be seen in figure 3.10 on the next page :

- **Plan:** By understanding the organisation's OH&S risks and opportunities, a Policy on OH&S can be established defining objectives, processes and the required resources.
- **Do:** Implementation of the processes as planned, while ensuring workers participation, hazard identification and emergency alertness.
- **Check:** Evaluate measures and monitor the processes and activities correlated with OH&S.
- **Act:** Actions must be taken in order to improve: incident detection, addressing non-conformance and audit detection.

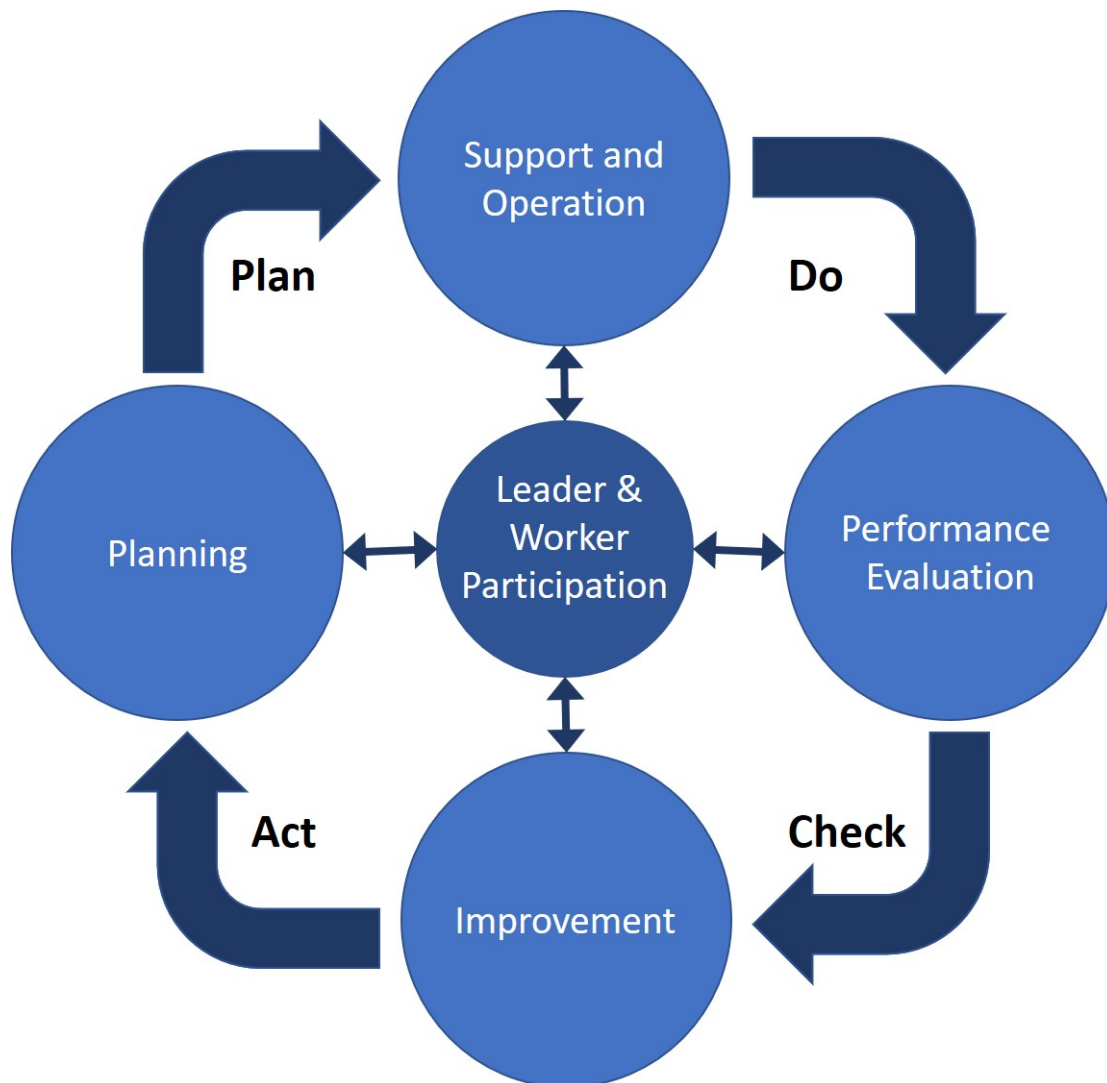


Figure 3.10. Scope of the OH&S management system (based on International Organization for Standardization (2018))

Annex SL formerly known as ISO Guide 83, contains 10 clauses. The first three create a background with terms of definition. The fourth clause is focusing on the system's necessary processes and requirements to achieve organizational policy objectives. This can be achieved by understanding the "Context of the organisation" in which it runs. The definition of the scope is taking place in this clause and the inception of the plan. The next clauses from five to ten are also used in other management systems. The OH&S processes should be found, applied and maintained while there must be hazards' identification, risk management control and worker participation. The Annex SL establishes an integrated management system which also meets the requirements of other ISO standards like ISO 9001 and ISO 14001. This can include documented information, procurement, audit and reviews of the management processes without duplicating. (Alister, 2018)

1. Scope
2. Normative references
3. Terms of definition
4. Context of organisation

5. Leadership
6. Planning
7. Support
8. Emergency preparedness
9. Performance evaluation
10. Improvements

The PDCA is separated in further sub categories this can be seen in figure 3.11. The Plan phase contains: Context of the organisation, Leadership, Planning and Support. While the Do phase contains operations, the check phase performance evaluation and The Act phase correlates with improvements. (Alister, 2018)

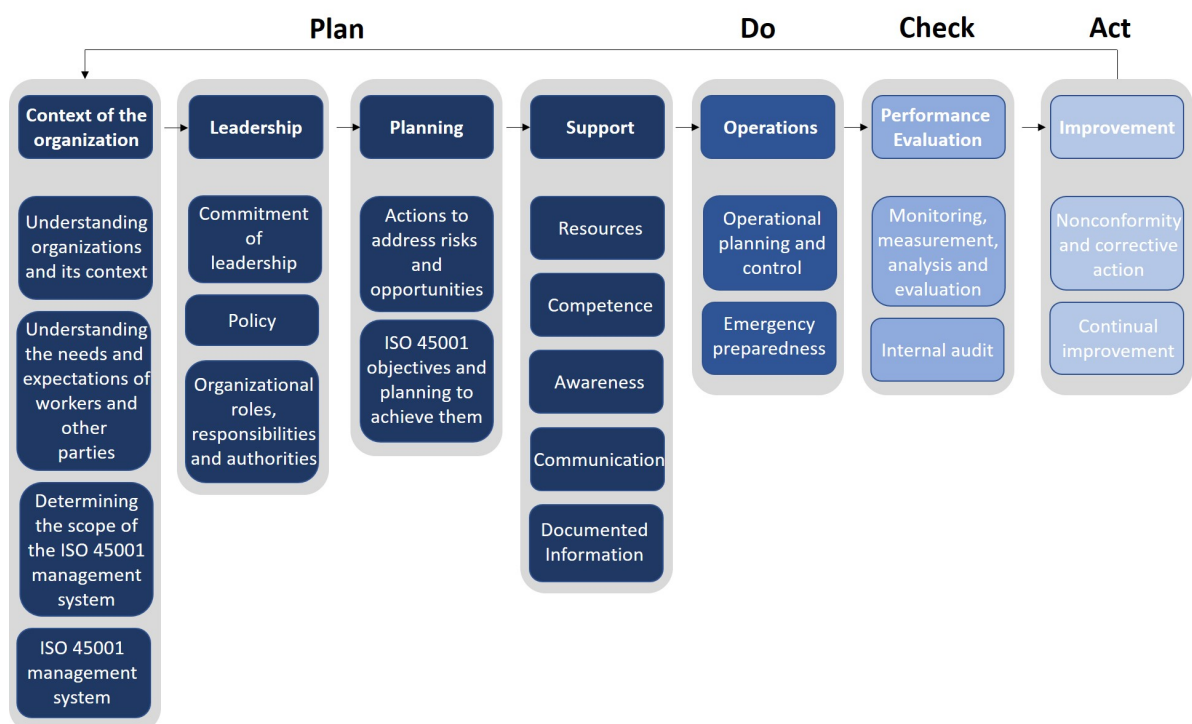


Figure 3.11. Annex SL Clause Overview (based on Alister (2018))

Additional information regarding ISO 45001:2018 (Wells, 2018)

- The certification of OHSAS 18001 has to be updated within three years to ISO 45001 standards.
- Companies that conduct work internationally may need to adopt it earlier than companies that have activities only in one country.
- For the companies that operate under the ISO 9001 or ISO 14001, it is much easier to adopt ISO 45001 as a result of the common practices that they have.

3.6.2 ICT in the building sector

For organisations to survive and prosper in an increasingly competitive environment today, they must adopt means to offer new products and services, they should be able to operate from remote locations and develop ways to do business. This cannot be achieved without information systems. (Laudon and Laudon, 2002)

Fryer et al. (2004) claims that this can be achieved in three principal ways:

- by processing the information faster
- by making access to information easier
- by optimizing decision-making control with the improvement of management information systems

Derived from the information technology, management information system, also known as MIS, is a management and organisational solution that solves problems that are rooted in the particular environment.(Laudon and Laudon, 2002). MIS consists of physical devices and software that transfer the data from one device to another. By securing information flow the great loads of data can be transferred quickly and efficient. In the UK the adoption of MIS found obstacles as the building industry was resistant in adopting new technologies. For a project manager it should be important to consider the improvement potentials of the communication processes as well as the reasons that could make the application of ICT to fail. Therefore, the knowledge that will derive from that can make easier to adopt the use of ICT in ways that align with the current cultural standards.(Dainty et al., 2006)

3.6.3 ICT innovations in construction

With the cost of computing technology falling significantly the last years, it became affordable for the companies to use it. Therefore, it revolutionized the communication between people. Some of the technologies that enabled it, are(Dainty et al., 2006) :

- Computer-assisted communication technologies that offers a variety of ways to contact people. For instance, video calls in which the people can be physically separated but still communicate interpersonal.
- Computer-assisted decision aiding technologies which are technologies that give access for information to people to make decisions.

It is fair to say that the above technologies are considered as a necessity rather than options in the present environment. (Huber, 1990)

Other examples of ICT innovations can include:

- **Computer Aided Design, also known as CAD, and Virtual Reality or VR.** The term CAD can include from freehand sketching tools to 3D systems that can carry out structural analysis. However, the use of CAD is not only limited to numerical operation such as cost estimation and structural analysis, but it has expanded into most of the mainstream design operations. VR software comes to supplement the CAD packages by allowing them to be visually presented in many more dimensions. With the use of the above the production of information gains significant advantages over manual techniques while the projects can be modified easier. (Dainty et al., 2006)
- **Project planning and estimating tools** are areas of ICT that can include Gantt diagrams, risk management and project planning. Nowadays these applications are supplemented with other applications that can facilitate the design and construction process as well as the interaction between them. (Dainty et al., 2006)
- **Communication of project productivity and performance** can be characterised as the tolls that measure and convey the project's performance information. Therefore such tools

can manage and monitor the project's performance in ways that can ensure the project's success. (Dainty et al., 2006)

- **Internet-based communication resources** Internet created new possibilities for businesses. Web-based applications transformed the supply chain by integrating new communication techniques (Duyshart et al., 2003). For instance, E-procurement (procurement for acquiring products and components), E-commerce (facilitating transactions for vendors and buyers) and E-collaboration (providing communication across the supply chain). The advantage that derive from such systems is the quick access to information as well as a common frame of reference. A study made by Weippert et al. (2003) in four projects in Australia the Internet-based Construction Project Management (ICPM) systems had been used. Although that ICPM solutions were offering a convenient, cheap and fast way of communication it wasn't conclusive that it was influencing positively the communication among the different project actors. Further research is needed to determine how to get over the current cultural barriers and the traditional work practices that can delay the transition to ICT tools adoption and ICPM systems.(Dainty et al., 2006)
- **Supply-chain management tools.** Electronic Data Interchange (EDI) is a technology that has an application in the logistics management and it has also been integrated in the construction industry the recent years. In addition some innovations have been implemented such as wireless technology, electronic tagging, hand-held devices, web applications and GPS. All together they allow material and components to be tracked during the execution phase. The advantages can be reduction of lost delivery notes and payment delays, improvements in material management and a reduction in defects. URL addresses with the electronic tags can allow access to manufacturer data and they can offer a a huge potential for E-commerce transactions.(Dainty et al., 2006)

BIM and safety

According to Hardin and Mccool (2015) safety at work can be enhanced by using BIM in the following ways:

- Fall Protection analysis (guardrails, scaffolding etc.)
- 4D site logistics simulation which can indicate which areas on a site that are dangerous and in each days
- Safety training site orientation
- Decreased ladder time and unsafe installation positions by increasing prefabrication efforts.

BIM has the potential to improve many areas in the building industry. By introducing automation, BIM can lead to safer projects. By reducing the hours worked on site, the likelihood of accidents is also reduced. (Hardin and Mccool, 2015)

Drones and Photogrammetry for Safer Reality Capture

Black & Vetch Engineering is using drones with Go Pro cameras to capture various images with existing building site conditions. Then with the use of software, these pictures are mounted together to form a model. This technique can be used in the telecommunication business to reduce risks that derive from climbing up telecommunication towers 120 meters to 300 meters. This can help to gather information safely by taking high definition photos without putting employees at risk. (Hardin and Mccool, 2015)

3.7 Organisational culture

The meaning of culture is broad, since it relies on the individual's perception, yet it is often perceived as the beliefs, attitudes, values and customs of any social human group, like for instance, a family, that are passed down through generations. (Acerbi and Parisi, 2006)

Thus, culture in the American Heritage Dictionary is defined as:

"The arts, beliefs, customs, institutions, and other products of human work and thought considered as a unit, especially with regard to a particular time or social group...The set of predominating attitudes and behavior that characterize a group or organization: a manager who changed the corporate culture." (Mifflin, 2000). (16)

The organisational culture of one company is strongly influenced by the initial beliefs of its leader or founder. However, these same beliefs can be maintained inside the company even after the founder or leader is not there anymore. (Van Den Steen, 2003).

Another definition of organisational culture is *"the way things are done in an organisation"* (Vazirani and Mohapatra, 2012).

Based on Schein (2004), the organisational culture is divided in 3 parts. As seen on figure 3.12, the three layers are **Artifacts**, **Espoused values and beliefs**, and **Basic underlying assumptions**.

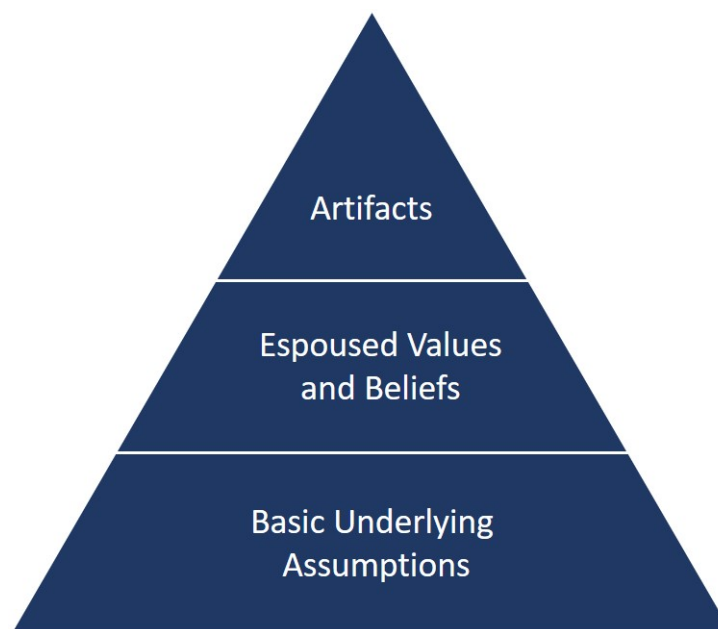


Figure 3.12. The three layers of culture (based on (Schein, 2004))

Artifacts

Artifacts are the most visual part of corporate culture, they can be seen, felt or heard by an observer. (Schein, 2004) Some of these, according to Schein (2004), are:

- **Linguistic** based on how the organization members interact with each other, what kind of language they use.
- **Technological** based on how they use technology and which types of technology.
- **Physical** based on how the offices are organised and decorated. if there is a dress-code requirement
- **Traditions and Events**. If there are ceremonies, social events, what management styles the corporation follows, the functions of the organization.
- **Stories and myths** what can be heroic based on types of individuals and acts.

Artifacts are the most easy to see in the organisational culture but they are the most difficult to understand. In order for the observer to understand them, he must observe them for a long time frame or go into the deeper layers of culture. (Schein, 2004)

Espoused values and beliefs

The espoused values and beliefs are the second level in the organisation value. This level reflect on how the members of an organisation believe the things should be. In that level the publicly stated values and behavioural rules are expressed by the corporation vision, motto, missions, values and philosophies. These things can be considered as the company's future. The mission statement reveals the purpose that guides the decision making in an organization. In addition, the mission statement is also describing the purpose and values of the corporation, while it guides the behaviour of the people and provides inspirational goals. The espoused values and beliefs are usually shared through the entirety of an organisation. If the previous rule is applied then an observer can predict most of the behaviour observed in the artifact level. But still for an observer to understand the corporate culture of an organization and not only part of the behaviours the espoused values and beliefs are not enough and the next deeper level of culture should be introduced. (Schein, 2004)

Basic underlying assumptions

In the deepest level of corporate culture the basic underlying assumptions can be found. At that level the observer might not be able to see all the elements of culture as it can be hard sometimes. The basic assumptions are taken for granted as they are deeply embedded in the corporation culture and they are almost impossible to change or modify. Therefore sometimes changes to that level of cultures are necessary if the organization is in a state of growth. This is characterised as the "DNA" of the organisation. (Schein, 2004)

As Schein (2004) proposes that the corporate culture reflects the challenges that an organisation faces, these challenges can be internal and external or matters that deal with the human nature and truth.

The basic underlining assumptions can be categorised in 5 sections (Schein, 2004):

- Assumptions about external adaptation issues.
- Deeper cultural assumptions about truth and reality.
- Assumptions about managing internal integration.
- Assumptions about the nature of space and time.
- Assumptions about human activity, relationships, and nature.

It is important to state that the categories above can not explain the whole meaning of corporate culture. It is the combination and interrelationships of the underlining assumptions that explain the culture. (Schein, 2004)

3.8 The concept of safety culture and safety climate

"Fostering a positive safety culture is fundamental and critical for improving safety performance on a construction site."

Dongping Fang
Haojie Wu

(Fang and Wu, 2013)

The expression **safety culture** was used the first time after the nuclear disaster that occurred in Chernobyl in 1986 in the International Atomic Energy Agency's initial report (Peterson Jr, 1987) and evolved from the aftermath of another disasters that took place mainly in Europe. Since then, an inquiry named The Piper Alpha, conducted by Cullen (1993) among other inquiries found problems in the organisational structure and identified the need for a systematic safety management, which brought the importance of safety culture to the public eye. (Health and Safety Executive, 2005)

The widespread definition of **safety culture** is:

"The safety culture of an organisation is the product of individual and group values, attitudes, perceptions, competencies and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organisation's health and safety management. Organisations with a positive safety culture are characterised by communications founded on mutual trust, by shared perceptions of the importance of safety and by confidence in the efficacy of preventive measures". (Booth, 1993) (17)

Other relevant definitions are:

"the attitudes, beliefs and perceptions shared by natural groups as defining norms and values, which determine how they act and react in relation to risks and risk control systems." (Hale, 2000) (18)

and

"those aspects of the organisational culture which will impact on attitudes and behaviour related to increasing or decreasing risk." (Guldenmund, 2000) (19)

Safety culture is a segment of the overall organisational culture which affects the attitudes and beliefs of the workers in regards to H&S performance. (Cooper, 2000)

Coming from these commonalities, the following definition provided by [Wiegmann et al. \(2002\)](#) suggests that:

“Safety culture is the enduring value and priority placed on worker and public safety by everyone in every group at every level of an organization. It refers to the extent to which individuals and groups will commit to personal responsibility for safety, act to preserve, enhance and communicate safety concerns, strive to actively learn, adapt and modify (both individual and organizational) behaviour based on lessons learned from mistakes, and be rewarded in a manner consistent with these values”. (20)

However, according to [Wiegmann et al. \(2007\)](#), the definition above is given *in neutral terms*, which means that the *organizational safety culture exists on a continuum* and that organizations can have either a good or bad safety culture.

Furthermore, the organizations in high-risk industries, such as the construction industry, are becoming aware of the safety culture's role in encouraging staff to behave safely which reduces further risks. ([Wiegmann et al., 2007](#))

3.8.1 Safety Culture Models

Safety culture, organization practices and safety management systems enclose the safety culture model. In some safety culture models, there is a tight connection between the safety culture and the organisational culture. In order to improve the connection among safety management, safety culture and socio-technical systems a new model was developed. This model targeted in integrating safety culture in the organisational structures and processes. ([Fang and Wu, 2013](#))

[Geller \(1996\)](#) in the **Total Safety culture model** as seen in figure 3.13 on the following page is combining 3 factors. They are usually called "The safety triad". These factors are: environment, person and, behaviour. It is important to state that "the Safety Triad" is only showing the composition of the safety culture and not the interactions among these 3 factors. ([Fang and Wu, 2013](#))



Figure 3.13. Total Safety Culture Model (Based on Fang and Wu (2013))

Another model that emerged initially from Bandura (1986) and completed by Cooper (2000) is the **reciprocal safety culture model**. As seen on figure 3.14 on the next page this model emphasizes in three elements: the person, the environment and the behavior. To an extend, this model separates the factors in two categories. The first one is the internal psychological factors in which the person as element is included. The second one is the external observable factors in which the factors of behavior and environment/situation are included respectively. This model forms a framework that can be used for business units and organisations. (Fang and Wu, 2013)

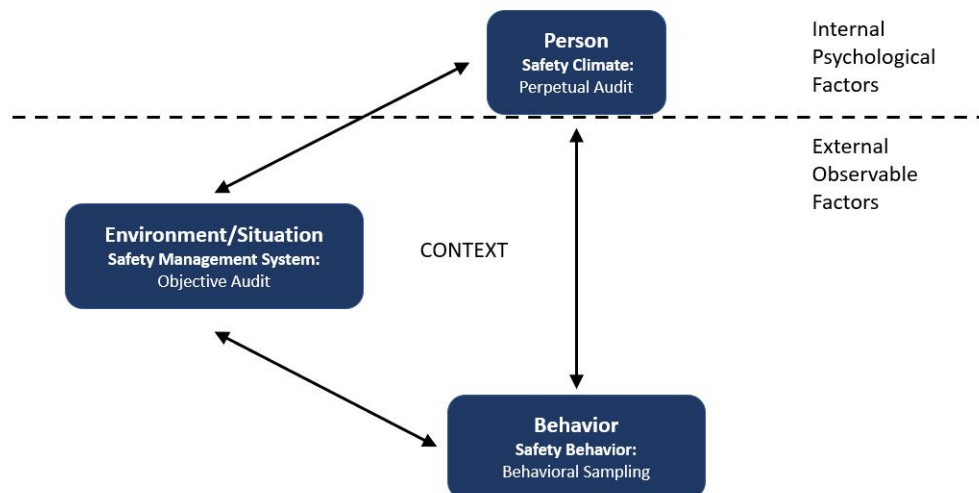


Figure 3.14. Reciprocal safety culture model (Based on Fang and Wu (2013))

Based on the two previous models, Choudhry et al. (2007) designed the **model of construction safety culture**. In that model, the research center is located around three pillars: safety climate, safety behavior and, safety management systems. This model gives a perspective of the variability construction safety culture. In this model, relations among *psychological* and *perceptual*, *situational* and *environmental*, and *behavioral constructs* were introduced while these relations could individually analysed or in combination with any other construction sites. In construction management projects the focus is on multi-party composition of the construction project safety culture and interactive dynamism. (Fang and Wu, 2013)

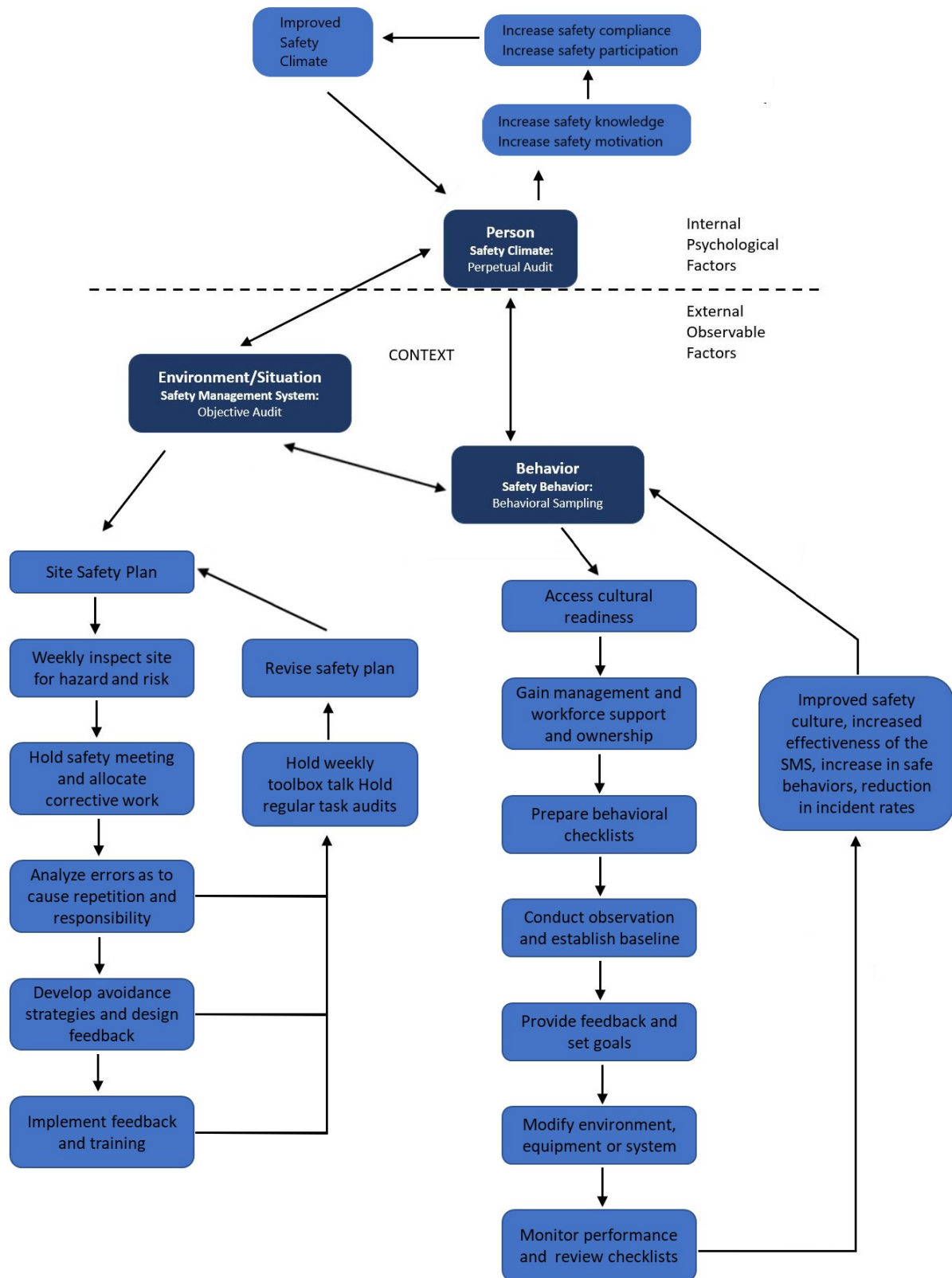


Figure 3.15. Model of construction safety culture (Based on Fang and Wu (2013))

As previously mentioned a construction project operation is dynamic and inconsistent while usually is managed by the project team which consists of owner, contractor and subcontractors. It

is possible to state that a construction project safety culture differs a lot from a company's safety culture. Therefore the nature of the task oriented and multi-party composition of the project team shows that the safety culture can differentiate from the head office to the site. This can be attributed to the task-oriented and the multi-party nature of the teams. The culture that is formed is a result of interactions between organisational safety cultures. The contribution of each party to the safety culture can be characterised as dynamic and interactive. The model that arise from these effects is called Safety Culture Interaction model and it is visible in figure 3.16. The letters appearing in the central triangle are interpreted "E" represent the environment "B" the behaviour and "P" the perception of the involved actors. (Fang and Wu, 2013)

Abeysekera (2002) claimed that culture in the construction industry is one of the key components along with approaches to construction, competencies of the craftsmen, strategies, goals and values of the organisations. Moreover, Cooper (2000) characterized the safety culture as sub-unit of the organisational culture. This comes down to individual while jobs and organisational features affect the the health and safety performances equally.

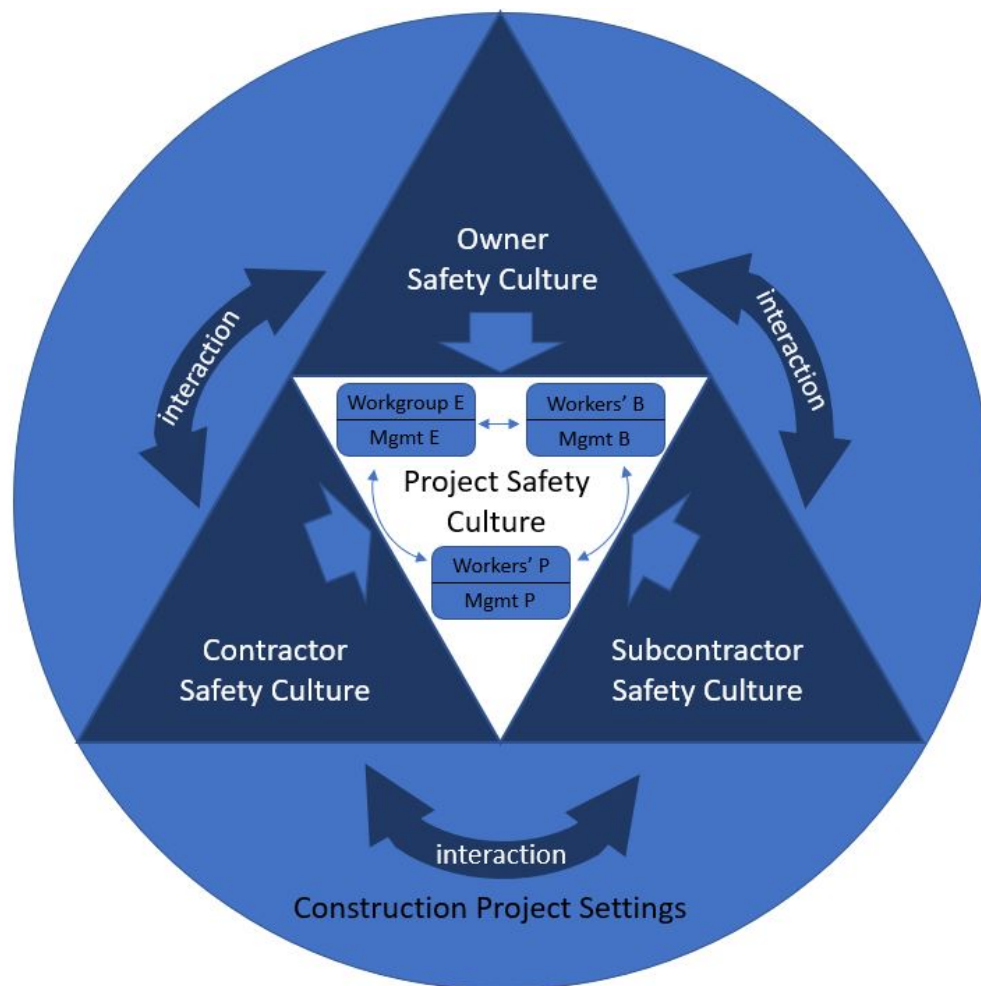


Figure 3.16. Safety Culture Interaction Model (Based on Fang and Wu (2013))

It is important to state that shared values, beliefs, goals and behaviors are interrelated or influence safety. The above can be considered as the first stages of a safety culture across an organisation. (Fang and Wu, 2013) As a result the above can also be considered as essential

elements of corporate culture according to [Schein \(2004\)](#) see also 3.7 on page 40. Therefore it is evident that there is correlation between safety culture and corporate culture.

Safety culture often is regarded as a subcategory of organisational culture. It is strongly advocated that affects organization members' attitudes and behaviours towards H&S performance and safety in general. Safety corporate culture is characterized as a sub-facet of the corporate culture which referees to individual, jobs, and organisation features which affect and influence H&S. ([Ambroz, 2015](#))

3.8.2 Safety climate

[Wiegmann et al. \(2002\)](#) found that the expression *safety climate* is often used interchangeably with the term *safety culture*. Yet, there is a difference between these 2 terms.

[Wiegmann et al. \(2002\)](#) suggested the following definition:

“Safety climate is the temporal state measure of safety culture, subject to commonalities among individual perceptions of the organization. It is therefore situationally based, refers to the perceived state of safety at a particular place at a particular time, is relatively unstable, and subject to change depending on the features of the current environment or prevailing conditions”. (21)

Safety climate is different from safety culture in 3 ways according to [Wiegmann et al. \(2002\)](#), with these following distinctions:

1. Safety climate is considered a psychological phenomenon, which is explained as the perceptions of the state of safety at a given moment.
2. Safety climate is characterized as a temporal phenomenon, a “close up” of safety culture, unstable and subject to changes.
3. Safety climate is closely related to intangible problems, such as from origin in situational and environmental causes.

As demonstrated above, there are 3 main components to safety climate such as the above mentioned: psychological, situational and behavioural. Examples of situational components are found in the main structure of the organisation like the policies, working procedures and management systems. Behavioural aspects can be measured through observations, self-report measures and outcome measures, whereas the psychological component is often measured by safety climate questionnaires which are originated from quantification of the workers' attitudes, behaviours, values, norms and their own perceptions of safety at workplace. ([Gadd, 2002](#))

[Glendon and McKenna \(1995\)](#) agree that the connotation of culture is that of one existing within an organisation, while climate has passive implications of being shaped by the external surroundings. This is confirmed by [Flin et al. \(2000\)](#) since in this research, safety climate is considered a distinct but related concept seen as the current surface features of safety culture, which come from the employees' attitudes and perceptions.

3.9 Communication in the construction industry

Cherry (1978) defined *communication* as the process of interaction between individuals in which *meaning is created and shared*.

Dainty et al. (2007) expressed that communication is in itself, a multiple and complex term, meaning different things in different situations and contexts.

For instance, this is exactly the case within the construction industry, where each construction project demands communication between various stakeholders.

Dainty et al. (2007) wisely recognized the importance of communication in the construction industry when stated that *"everyone involved in construction plays a part in a complex communication network. Seeing the project environment as an interconnected network of actors is appropriate because every such venture, no matter how small or well defined, can be successfully completed without interactions and transactions between people and organisations."*

Effective communication

Glendon and McKenna (1995) stated that organisations with a positive safety culture make use of effective communication. The effective communication is based on shared beliefs of the importance of mutual trust, safety and confidence in the success of the preventive actions for safety. (Glendon and McKenna, 1995)

According to Glendon and McKenna (1995), an important index of safety culture is effective communication which leads to ways to attain it through the collective goals and means to achieve these goals.

The building segment relies on information being exchanged among the different involved actors of a construction project, therefore, this kind of communication must be effective. (Pozin et al., 2018)

Paraphrasing Pozin et al. (2018):

"Effective communication is becoming increasingly important in project construction because of the growing demands of the projects, along with the heavy amounts of technical work and the complexity of the supply chain process." (22)

3.9.1 Safety communication

It is discussed among researchers that if safety hazards are not properly communicated, the likelihood of occurrence of onsite injuries due to hazard exposure increases. (Albert and Hallowell, 2017), (Jeelani et al., 2017)

As mentioned before in subsection 1.2 on page 2, Vecchio-Sadus (2007) indicated that safety communication is related to the procedures and rules at the workplace, regulations, performance statistics, hazard and accident reports, risk assessments and construction crew's training. By

ensuring prompt and effective communication during the construction period on the building sites, the construction staff engages into a safer daily practice on the work-site, ensuring cooperation among the team while keeping a positive safety culture altogether. (Vecchio-Sadus, 2007) Moreover, in order to improve safety culture, it is crucial that the organizations provide information about safety improvements and at risk prevention actions on the building sites through prompt and effective safety communication. (Vecchio-Sadus, 2007)

A study made by Dingsdag et al. (2008) suggested that foremen indeed possess a stronger influence on construction crew's safety behaviours than the co-workers. This study was corroborated by the study made by Kines et al. (2010) in Denmark back in 2010.

Kines et al. (2010) investigated the outcome of improved verbal safety communication had on onsite safety in Denmark. Firstly, looking at leader-based communication, where, the foremen of 2 different building sites, were coached in verbal safety communication and given biweekly feedback on their progress. The foremen included safety in daily conversations with the crew, reaching a positive effect on onsite safety. During the study, safety communication and levels of onsite safety increased on these 2 building sites, whereas on the other 3 control construction sites, there was no notable trend changes on the onsite safety over the same period of time (up to 42 weeks). This study concluded also that a boost in safety communication did not result in a decline in communication about quality of work or production.

Actually, nowadays, where COVID-19 became pandemic, communication can either improve or impair the H&S program of the company. The unexpected and sudden arrival of COVID-19 outbreak has also given the construction managers a priceless hint that prompt, suitable and effective safety communication is the key for the appropriate compliance of onsite H&S even during the H&S interruptions. (EHS Today, 2020)

Safety communication can be enhanced with technical strategies. The methods are separated in internal and external. (Vecchio-Sadus and Griffiths, 2004)

In internal communication methods are included the following (Vecchio-Sadus and Griffiths, 2004):

- presentations to senior management
- staff and HSE committees
- team meetings
- emails
- videos
- noticeboards
- newsletters
- poster displays and signage

In external communication methods are included the following (Vecchio-Sadus and Griffiths, 2004):

- annual reports
- publications
- telephone enquiries
- following the changes of legislation

The information of the previous mentioned should be in a easy to understand manner. Limitation should be considered also like people that do not have access to electronic content or different language speakers. (Vecchio-Sadus, 2007)

- **Statistics** can give useful information to the organisation through graphs of lost time, medical treatments, workers compensation, severity and incident rates and performance indicators. The above can give a valuable input for improvements in the HSE. (Vecchio-Sadus, 2007).
- **Safety induction:** On site rules and requirements and emergency procedures should be introduced to new employees, visitors and contractors in order to carry out their duties safely. (Vecchio-Sadus, 2007).
- **Risk assessments** can identify hazards that expose worker to a risk of injury. There are risks that are visible and obvious like moving parts of a machine or heat producing equipment, but there are also risks that are not visible or can't be perceived by the worker, for instance dangerous gasses that have no smell (Carbon monoxide). (Vecchio-Sadus, 2007). In 3.5.1 on page 31 risk assessments are further analysed.
- **Manuals, checklists and operating procedures:** The manuals consist of rules that consolidates the requirements for working safely. With the checklists the organization can monitor and increase hazard reporting, ensure better operation of equipment and help make decisions for operation. Operating procedures offer consultation on safe work practices. (Vecchio-Sadus, 2007).
- **Hazards, incidents and near-misses:** By reporting an incident to the workers and address the reasons for the incident, the management shows commitment to safety. The involvement of the staff on suggesting strategies can produce a desire to implement these strategies. Usually employees are not willing to report incidents and injuries so that should be encouraged by promoting campaigns. (Vecchio-Sadus, 2007).
- **Training** can be considered as a proactive measure. Programs like this can create positive attitudes from the staff towards HSE. Training in safe work methods should encourage workers to adopt values of Health and Safety. An example of a situation that the workers doing their work faster cutting corners so that they can take a longer break while their first priority should be their safety. By putting in comparison working safely or finishing earlier can make the workers understand how valuable asset is safety. (Vecchio-Sadus, 2007).
- **Safety week:** By organising safety weeks the management can promote a happier and healthier workplace and simultaneously increase awareness about H&S issues. In the event of the safety weeks, activities like seminars, videos, evaluation drills, health checks can take place. (Vecchio-Sadus, 2007).

According to Vecchio-Sadus (2007), there are some techniques for enhancing safety communication in the work environment, such as for instance:

- Understandable written rules
- Identification of communication lines between managers and construction crew
- Communication taken in the language of the worker
- Feedback
- Instructions given effectively and promptly
- Development of speaking skills and effective questioning in order to give and collect information
- Listening skills are needed in order to meet the needs of the construction crew

There are some systemic barriers to effective safety communication in the building sites, such as differences in culture, gender, and language proficiency. (Alsamadani et al., 2013), (Allison and Kaminsky, 2017), (Chan et al., 2016), (Gamil and Rahman, 2017), (Al-Bayati et al., 2017)

The organisation can continuously improve communication by making sure that workers are kept informed on the objectives towards a better H&S environment by using channels such as tool-box talks, safety forums, newsletters, e-mail, bulletin boards, safety briefings etc. (Gadd, 2002)

3.9.2 Communication strategies

Communication strategies do not constitute an "objective" class of phenomena. Communication strategies are cooperative in nature. The interlocutors are both aware if there is communication problems and then they try to solve this problem based on cooperation. The problem comes on the surface when the performance is disrupted. Consequently, one of the approach that is presented is the two types of communication strategies: *direct appeals*, in which the interlocutor attempts to solve the problem alone, and *indirect appeals*, where the receiver provides the solution eliciting the interlocutor's participation. Another approach can be on the behaviour the two users can have. The individuals can either adopt *avoidance behaviour* by renouncing their original goal or *achievement behaviour* by trying to maintain their original goal and develop a second plan. These two previous behaviours lead to two different communication strategies the reduction strategies and the achievement strategies respectively. (Færch and Kasper, 1984)

Feedback

One of the most effective ways for the safety culture to improve and prevent accidents is the achievement of a good communication regarding safety. The Safety Culture Survey figured out that only 60% of the employees give critical feedback to their employers. The respondents claimed that by giving safety related feedback will create interpersonal conflict. Another reason that discourage people from giving safety feedback is that they don't want to insult coworkers with more experience. Many concluded with the phrase "*It's not our job to give safety feedback*".(Williams and Geller, 2008)

In fact 74% of the people responded to the Safety Culture Survey verify that they would welcome peer observations for receiving safety related feedback. Yet, only 28% support that other fellow employees feel the same. Employees can be more open to safety related feedback if fellow workers can provide and receive it.(Williams and Geller, 2008)

In order to give effective and corrective feedback to co-workers, especially when they work at high risk, "Don't make it personal - Focus on behavior". The interaction should be promoted by asking questions in order to facilitate discussion, it should **not** be like a lecture. Feedback should be given immediately one to one revealing genuine concern for the person's feelings and well-being. By offering the opportunity to work together so that new solutions can be found, can also be a factor of improvement. Last but not least, the person should be thanked for his/hers cooperation. To receive corrective feedback the receiver should not interrupt the flow and listen carefully. He should remain open and not to get defensive. There must be discussion of better ways of doing the job and finally the receiver should thanks the provider. Another important factor is to cautioning co-workers that have operating at-risk and praise them for performing their tasks safely. By doing that a more open, positive safety culture climate is created and the likelihood of these work practises increases. (Williams and Geller, 2008)

However, according to Williams (2002) the practice of receiving one to one praise or appreciation is staying at a low percentage. (Williams and Geller, 2008)

Communication styles

A factor for safety communication is the different communicating styles that people adopt. According to Brounstein (2001), there are four basic communication styles:

- The dominant communicator.
- The passive communicator.
- The passive-aggressive communicator.
- The empathetic communicator.

It should be mentioned that the three first styles are not very effective in building a total safety culture while the forth is more likely to promote it. (Brounstein, 2001)

The Dominant Communicator

Dominant communicators tend to "run people over" in conversations. This type of communicators believe that they are never wrong and evaluate their opinions higher than others. They characterize the people who disagree with them disloyal and misinformed. These practises lead to bad behaviours like public criticism of others, blaming third party people when problems arise, bossy and negative attitudes, verbally aggressive and sometimes threatening language, lack of appreciation for others' accomplishments, interruption of other people's speech, dismiss new idea without even listening to them. Dominant communicators spread a sense of fear counter control and alienation. Some characteristics of the behaviour of these people are resistance, retaliation, defiance, sabotage, formation of alliances, lying and covering up situations. Corporate culture and moral are being damaged by these types of behaviour while the organizational performance drops. (Brounstein, 2001)

The Passive Communicator

Passive communicators believe that the people should not express their true feelings and also not to disagree with others. They also tend to turn people off for being indirect in their interpersonal communications. They usually believe that other's people opinions are more important than theirs. By doing that it leads them to maladaptive behaviour such as remaining quiet, even if they are being treated unfairly. Therefore asking permission unnecessarily, frequent complaining about others and delegating their choices on others are also some characteristics that should be mentioned. As a result passive communicators accept directions without question by avoiding confrontation. This type of behaviour creates an environment of disappointment and mistrust while passive communicators lack the qualifications to be a leader. (Brounstein, 2001)

The Passive-aggressive Communicator

The communicators that belong to that group believe that they should "go behind people's back" instead of dealing with people directly. They show that they agree with others but in reality they don't. They usually use sarcasm and when they send critical messages by email they notify others as well. These kind of people hold grudges, they make use of the "getting even" tactic while some times they sabotage others behind their backs (spreading rumors or gossiping). Passive-aggressive communicators usually refuse help to others. (Brounstein, 2001)

The Empathetic Communicator

Empathetic communicators take into consideration others people's opinions and theirs while, emphasizing on the importance of process of decision (not just the outcome). They believe that acquiring input from other boosts morale and generally leads to better decision making. Usually these beliefs create communicating expectations rather than demands. The focus is on proactive, action oriented conversations with a tendency to realistic expectations. The communication takes place in a direct and honest manner and work between parties to achieve goals but without compromising others. Empathetic communicators embrace the perception of autonomy and motivate people in achieving goals while increasing the sense of "go beyond the call of duty" for the enterprise. They facilitate the sense of appreciation and respect, which leads to interpersonal trust, honesty, respect and openness. The result is enhanced organizational communication with higher moral and increased performance. Companies with empathetic communicators are more likely to have healthy organizational cultures. (Brounstein, 2001)

3.9.3 Communication Barriers

Types of barriers

The individual's frame of reference happens when people interpret a message in their own way. For instance cultural differences can shape the way an employee reacts to a change when wearing a H&S equipment as in some cultures it could be perceived as a "doctrine" that must be complied with. (Loosemore et al., 2003)

Stereotyping is defined when people organise other people based on their socially constructed views. For instance, instead of listening to others they will expect the other person to say an opinion based on their socio-economic background, profession or perceived dispositions. This situation can lead to decisions that are not in accordance with the current situation. (Loosemore et al., 2003)

Cognitive dissonance: When someone receives information that are in contrary with their beliefs then they will face difficulty in accepting or responding positively in the other's people opinion. It is almost certain that they will disbelieve or challenge that new information. (Loosemore et al., 2003)

"Halo or horns" effects: If someone is trusted by another person there is a chance to be predisposed to agree with what they say. Subsequently, if someone is distrusted then what they say might be ignored. This type of barrier can be correlated with stereotyping but the "Halo or horns" effects are focused on the individual than on a social group. (Loosemore et al., 2003)

Semantics/jargon: In that situation the message finds difficulties in transferring the meaning from one person to the other. The meaning is attributed to the receiver and is not properly explained with words. For instance if a term is used and it is not understood by the receiver then the whole message is lost. (Loosemore et al., 2003)

Not paying attention: By being distracted by a noisy environment the receiver usually forgets the information soon after the communication has taken place. Also there are factors that contribute to that phenomenon such as occupational stress and burnout. Therefore these can affect the person's ability to memorise the message leading to low concentration and reduced performance of the individual employee. (Loosemore et al., 2003)

Mehra (2003) defines ten barriers to communication:

- *Physical* barriers such as noise, time, distance, environment and the medium.
- *Cultural* barriers separated in ethnic, religious and social differences
- *Perceptual* hearing what was said with the receivers prospective.
- *Words* sometimes are assigned with a meaning usually because of culture or experiences. This can result in wrong encoding of the message.
- *Experimental* when the sender and the receiver are lacking common experiences.
- *Emotional*, personal feelings or being occupied with other stuff besides listening.
- *Linguistic* barriers described as the different languages or the vocabulary used
- *Non-verbal* as the messages without words
- *Gestures* that can be misinterpreted can be a major barrier.
- *Variation in language* expressed like different accent or dialect.

Cultural barriers

Kartam et al. (2000) stated that different labour cultures, traditions and work habits of the migrant workers affect safety. Therefore, it is important to make a systematic review upon the role of the migrant workers in Denmark, as the PG sees that this type of barrier is mostly related to safety communication on the construction sites, thus connected to onsite injuries.

Migrant workers

The globalisation of the workforce is one of the major development traits of the construction industry, which creates a multicultural workplace in a building site. (Information, 2019) After the expansion of the European Union in 2004, the number of migrant workers increased from the new member countries across Western-Europe. (Arbejderen, 2014),

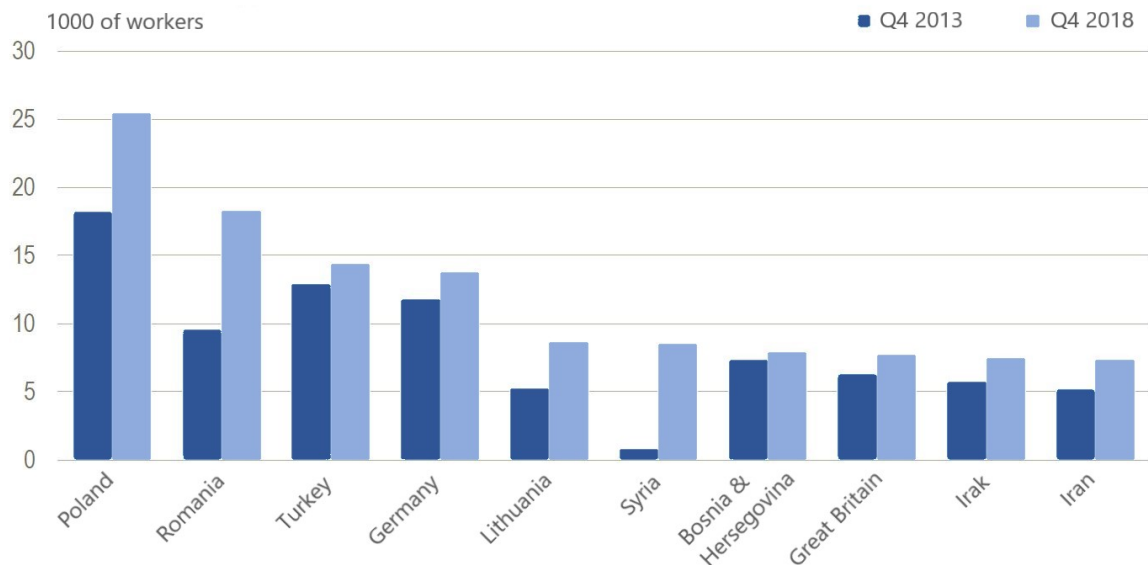


Figure 3.17. Number of immigrants with jobs in Denmark by country of origin, 4th quarter of 2013- 4th quarter of 2018, based on (Danmarks Statistik, 2019)

In Denmark, construction workers coming from Poland represent the largest group of migrant workers, (Danmarks Statistik, 2019), (Arbejderen, 2014), Information (2019), as shown in figure 3.17. In fact, in the 4th quarter of 2018, the Polish construction workers represented 11,8 %

of the total of migrant workers in Denmark, whereas Romanian and Syrian construction crew represented 5,5 % of the total of foreign workers in Denmark, as seen in figure 3.18 (Danmarks Statistik, 2019). The number of migrant workers is continuously increasing since the native workforce in Denmark is not enough to cover the needs of the construction sector as well, *in order to maintain economic growth*. (The local, 2019) As a result, the job vacancies are filled by migrant workers.

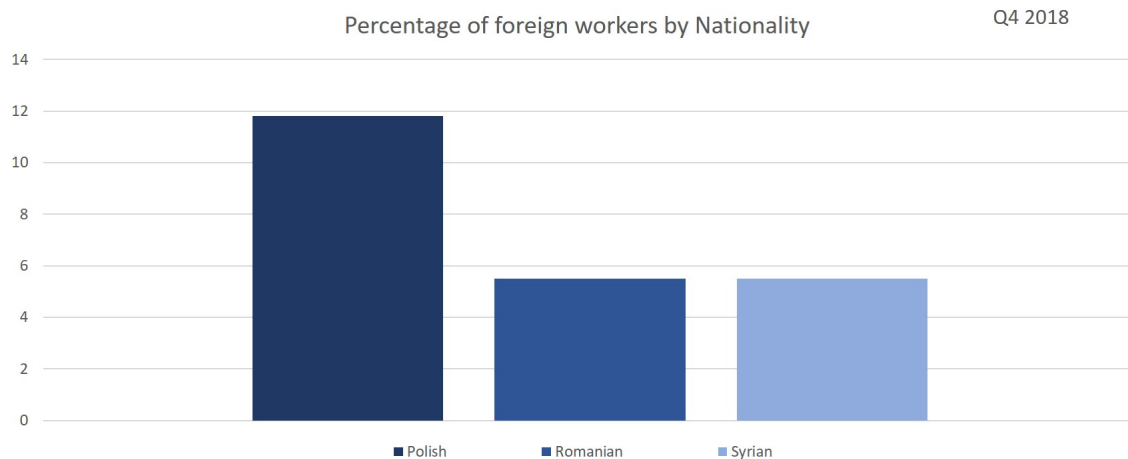


Figure 3.18. Percentage of foreign workers registered in the construction segment in Denmark, 4th quarter of 2018. (Based on (Danmarks Statistik, 2019))

With the rise of numbers of migrant workers in the construction segment in Denmark, challenges concerning an international workforce arise as well.

Mohamad (1999) suggested that poor communication is a massive issue dealt by the construction segment. Thus, Ngowi (2000) stated that this problem comes from the fragmented nature of the construction industry during the design phase and is amplified by the language differences or by the communicating culture of the staff.

Field studies show that language affects the safety at work. (Lindhout et al., 2012) Different labour cultures, traditions and work habits of the migrant workers are considered as factors that affect safety. (Kartam et al., 2000)

Furthermore, a study performed by Biering et al. (2017) concluded that there is a higher risk of work-related injuries among migrant workers when compared with native workers from Denmark. In fact, Salminen (2011) suggested that the risk of occupational injury is actually 2.13 times higher for migrant workers than for native workers.

The migrant workers represented a total of 16% of the workforce in the Danish construction sector in 2019. (TV2, 2019) Therefore, H&S rules have to become a top priority for the management team in the construction industry especially when migrant workers are employed on the building sites, as the construction segment is already recognized as one of the most dangerous industries in the world with the most work-related injuries and deaths (International Labour Organisation, 2015) and due to the knowledge gap on H&S rules and language barriers.

Problem formulation

This chapter starts with the answer to the initial problem statement and the unveiling of the final problem formulation which is the foundation of the next chapters of this research.

4.1 Answering the initial problem formulation

The **initial problem statement** given in Chapter 1, section 1.5 on page 4 is:

*How can effective communication improve safety culture
in the building industry?*

The initial problem formulation shown in the chapter 1 focused on how the effective communication could improve safety culture on the building sites and by doing so, it could mitigate or decrease the rate of incidents and fatalities in the building industry.

If safety risks are not *effectively communicated*, and approachable safety actions are not assessed, the increase of risky attitudes and the likelihood of onsite incidents are expected. (Alsamadani et al., 2013), (Allison and Kaminsky, 2017)

Vecchio-Sadus (2007) argues that communication and consultation at the workplace is known as an important tool for accomplishing a safe workplace where safety communication is a top priority. In a safe workplace, information, about hazards and control of risks, is given by the management and received by the construction crew since the used technique is an open two-way communication system, and by doing so, attitudes and actions are influenced in a positive manner, where construction commitment and ownership become present among the staff providing an understanding of how to work safely onsite. Furthermore, communication skills in the work environment are enhanced by solving issues together as a team.

As shown in table 4.1 on the next page, there is a connection between safety culture and communication. In order to correlate one element to the other and achieve a positive safety culture, a practical requirement is needed. For example in order to implement H&S regulations and decrease the operations risks on the building sites, and at the same time to engage the staff for showing their commitment and expectations to their supervisors, it is necessary to become involved in the H&S, take responsibility and action regarding onsite H&S and change attitudes towards the risky situations.

In fact, effective communication techniques are paramount for the participation of the crew into safe activities, and to show collaboration and engagement for keeping a positive safety culture. It is clear that when a worker possesses skills on effective communication, he or she is able to give *constructive feedback* on risky situations which decreases the risk of an injury to occur onsite, as well, when the worker, by using effective communication, gives a *rewarding feedback* for safe

| Safety Culture Element | Requirement | Communication Element |
|---|---|--|
| Applying methods for hazard control | Support from everybody | Safety of work can be reminded by displaying rules and processes |
| Implementation of Health and safety regulations and minimisation of risk in operations by the management team | Accept responsibility for HSE. Get involved with HSE. Provide resources. Change of mentality towards risk. | The employer must show commitment, values and expectations. Work performance should be monitored. |
| When trust and cooperation are embedded in organisational culture employees contribute most effectively. | Trust, encouragement and reward in terms of HSE. | Motivating staff. Recognising and rewarding milestones and achievements Feedback regarding HSE. Assessments of competency and revision of training when needed. |
| For the employees to behave and work safely the necessary information and training must be given. | To implement reforms willingness and competence are necessary. | Providing guidelines on how to operate safely with equipment, tools, materials and processes |
| An environment that promotes a framework for consultation and communication lead to contributing more effectively | Employees encouraged and volunteer to report errors and near-misses | Meetings with objectives such as hazard and incident reports, risk assessments and operating procedures |

Table 4.1. Safety Communication elements based on (Geller, 1998),(Australian Standards, 2001),(Reason, 2002),(Comcare, 2004),(Vecchio-Sadus and Griffiths, 2004), (Hopkins, 2005).

actions, the likelihood of such actions being repeated safely onsite in the future is higher, which improves consequently, the safety culture within the organisation. (Vecchio-Sadus, 2007)

The improvement of communication can be pursued where effective communication is achieved by the implementation of a communications management plan, this is a tool used in project management for establishment of a planned, structured, tracked and implemented communication within the company. (PMBOK Guide, 2017)

However, this problem statement is considered too broad for the confines of this master's thesis, therefore another problem statement is presented below in the following section, due to the fact that there is a correlation between the rise of incident and fatality rates in the building industry, and safety communication, as well the final problem formulation will suppress the knowledge gap within onsite safety communication nowadays and during the outbreak of a highly spread infection, like for instance the outbreak that the world is facing together right now, COVID-19.

4.2 Problem statement

Since the main concern of this research is to provide ways of decreasing the amount of incidents and fatal accidents in the construction industry and due to the fact that poor safety communication among the involved actors of a building project is considered one of the reasons leading to injuries

onsite, it seems therefore compelling to investigate how a company in the building industry can improve its safety communication, which imposes the following question:

How can safety communication among the involved actors on the building sites be improved during the execution phase?

The answer for this problem will be exposed in the conclusion of this research study.

Data Analysis

The chapter 5 contains the research data gathered through qualitative interviews. The main purpose of the data analysis is provide insight to whether the issues concerning H&S risks and communication complies with the presented literature review in chapter 3. The data analysis is carried out by giving answers to the research questions with statements from the interviewees as well the findings from the data analysis.

5.1 Qualitative Interviews

With regards to the interviews, the focus of the data analysis is on how the participants foresee safety management, safety culture and safety communication engaged on the building sites and the respective use of preventive safety measures.

5.1.1 Procedure

Interviews were conducted individually, where the participants answered questions during the qualitative interviews. All the two participants were informed about the research by the interviewer and that the interview would be recorded for reliability and validity purposes.

5.1.2 Variables

Safety culture

When asked about if all accidents can be prevented on site, the interviewee 1 said that both likelihood and consequences of accidents can be minimized:

...I don't believe that everything can be avoided, but that you can minimize as much as possible both the likelihood that it happens, if you do a good maintenance on the tools and all the checks that are necessary and so on.(lower the likelihood) Also if you follow the rules of how to use it and of how to protect yourself, you lower the consequences...if people believed that it could always be avoided than it wouldn't be a need of protection, because it wouldn't happen so I believe that happens, but you can make it as not as a big deal, if you protect as well. (23)

Regarding onsite safety as a top priority, the interviewee 1 said that the construction staff tends to neglect risks sometimes in order to increase productivity:

I don't think it is top priority for everybody, but I am not always on site so I cannot check what people do all the time. But sometimes, when they are used to do something, it goes faster. Maybe there is a small risk but people access it as then it will go, you know, when you do things many many times, sometimes you just neglect a bit security because it went fine a thousand times, why shouldn't it go fine the 1001st time? (24)

Concerning the ways that implementation of the H&S rules on the building sites are done, the interviewee 1 mentioned that:

There are several things, we use of course, the guidelines concerning how to use the tools, how to lift them, how to hang things with the cranes, so on...onsite we have to follow the rules and the things that the Work Inspection gives, but we have our foreman onsite that is coordinating the things, that makes sure that the things are made as they should.. We do risk assessments, but this is prior to our work onsite, so for every project, we make the plan for safety and it includes a risk assessment... (25)

The interviewee 2 wanted to give emphasis that safety is very important for them and they try to have the least amount of accidents and comply with the safety practices by saying that:

We don't build the hospital for for the construction site, we build it for the society. We don't want the worker to be a patient, because of the job that they had... (26)

The construction workers have access to the safety information onsite. They have a handbook with them. The interviewee 2 stated that:

We have the handbook, everyone on site has a small book with the rules in their pockets. (27)

The risks increase as the construction site's size increases. This can be noticed by the answer given by the interviewee 2:

The implementation of H&S rules is the same all over construction sites, But the risks are greater in larger construction sites. (28)

Regarding training, the crew has safety training once in a while and in accordance with the rules of some building sites, like stated by interviewee 1:

...They (the workers) have training for new equipment once in a while, some sites requires also a specific training for that project... (29)

The construction staff gets training before they start working onsite, stated by interviewee 2 as:

They (the workers) have to take a 2 hours course before they start working on the site, no matter if they have 15 years of experience (30)

Safety communication

The open ended question asking the respondents to give general suggestions on safety communication was analyzed by coding the answers into categories and frequency.

Firstly, the most cited answer was 'communication is orally' and 'communication is verbal person to person'. This refers to the direct communication on the building sites orally or with radios/walkie talkies.

Secondly, 'communication is big' was mentioned, this refers to the communication aspect relationship to the success of the projects.

Finally, respondents' statements are transcribed below.

The communication on the building sites is done orally, but foreman are responsible to daily communication among the other trades, as the interviewee 1 stated:

...Orally, with or without radios... The foreman leads the team, plans with the project manager, and has the daily communication with other trades onsite. (31)

There is direct communication between the actors involved. This can be seen from the answer given by the interviewee 2:

On site there is verbal person to person communication only when we have the big cranes for the big loads, they have the walkie talkies..... there are the driver and 2 spotters on the ground. (32)

The issues are arranged in a direct way when problems arise on site. This can be seen in the answer of the interviewee 2:

The only way to solve this is to go there with the persons involved so we have to go down there with the colleagues and look into it and say "how do you solve this?", that's the only way to solve it, when you are in the construction phase. You can't solve it from your desk.... They say I can't fit this there, it's no room for me here. (33)

There are people who don't follow the H&S rules because they overestimate their skills. The following comment can verify that people compensate sometimes the rules and increase the risk for themselves.

When people are lazy and don't want to use the right tools and just take a ladder climb up and do their own things because They have good balance. That is again the "superman theory" he can fly so can do that himself and there is no tolerance on that. (34)

With regards to whether communication helps the successful project to be achieved, the interviewee 1 suggested that communication allows to find, discuss and solve the issues that occur onsite:

...It allows to find the potential problems, discuss them to find a solution and solve them. This concerns both technical problems, human tensions (human conflicts can start the safety problems, if people are arguing they are not focusing on what is going on security, people drop tools), logistic problems, planning and security...The more we communicate, the more we can exchange communication and do the work well, not just in the safety perspective, but on the quality perspective too. (35)

Communication is a leading factor on the success of a project, according to interviewee 2:

Definitely communication is "big" in risk management both one on one and in general terms. (36)

The communication about hazards follows a procedure that is explained by the interviewee 1:

Communication about hazards is done by startup meeting on site and with the crew, reading the health and safety plan (PSS), making and submitting and discussing the Arbejdspilsvurdering (APV) and risk assessment before start of works onsite. Then, safety meetings every second week on longer projects... (37)

Safety management

The open ended question asking the respondents to enumerate the key challenges concerning safety management was analyzed by coding the answers into categories and frequency.

For the interviewee 1, communication and training are seen as the key challenges concerning safety on the building sites.

...More communication is always better. Even though we think that only instructions are passed on and so on that we gave all the equipment..there are maybe things we forget.. To be sure that we say everything that could be useful... Even if we did everything, inform everything, given all the equipment, in the end it is up to the person who has to do the task and wear the equipment to decide if they are going to do that normally, if they are going to do something different, not use the equipment as it should...so, the main challenge is ...the person who will do the task will decide if they will do what they should or if what they are doing is safe enough or if they will take a risk... Training- make people understand the risks.. and the consequences they could have. (38)

When asked about who has the responsibility of checking if the workers are using personal protective gear, PPE, and what happened if they are not using them on the building sites, the interviewee 1 said that the responsibility is that all workers use PPE, and remind it to each other, as well if they refuse using it, they cannot work onsite:

It is each and every workers' responsibility. The responsibility is to make sure that even though all instructions are passed on, equipment is OK and so on, the workers do as they are supposed to. If they are not using, the other workers need to remind it. If someone refuses, then they can't be working on site... It has not happened as I know of... (39)

There is zero tolerance on disobedient of the H&S rules in accordance to what the interviewee 2 stated:

There is zero tolerance strategy around people like those (people who don't follow the H&S rules)... If they can't obey (the safety rules), they have to go away. (40)

Some workers hesitate in giving feedback because they don't want to waste time for that. This derives from the following quote given by interviewee 2:

I know many of the people on site they don't tell everything, because there is bureaucracy, you have to fill a form, you have to talk to people like us... It's like a mother conversation and that is something you don't wanna spend time on a construction site... Many people on the site are getting paid for on how quickly they do their job and some of them are paid monthly, but when someone are payed by the hour they don't wanna discuss... I thing that can be an issue that time is money. (41)

A description of a bonus scheme is introduced by the companies for an accident free environment of 100 days, as stated by interviewee 2:

Many of the big companies have (a bonus scheme) if you have 100 days without an accident we give a free meal or a bonus, and if you are the one who gets injured in the day 99, do you tell them? Will you be the reason that everybody will lose their free meal or bonus. You don't do that, you just continue working on. (42)

The workers have access to psychological support when they are traumatised by an accident, in accordance with the statement provided by interviewee 2:

There was an incident with a heart attack in the construction site the construction manager called in every worker who was around that person and gave them crisis help with a psychologist if they needed. Some of them continued working but some of them were very affected because they were doing CPR and were emotionally affected. (43)

In the question if there are H&S plans before the commencement of the project, the interviewee 2 gave the following answer, that reveals that the use of templates is a common practice:

Sadly I think it is mostly templates(from the companies)... Very very little customization. We (Regional authority) need to give a focus on the planning of the H&S issues more in the beginning of the project ... (44)

BIM

The use of BIM tools help to address situations for H&S on the building sites:

The Dalux software is used... (45)

For interviewee 1, BIM tools can improve the overall safety on the building sites:

...We design all projects in 3D... By planning everything very well with BIM tools, it does not require imagination... people can see how it looks like, so we avoid uncertainties as much as we can, and therefore avoid "bad solutions" onsite... Difficulties are known ahead, and can be solved safely. (46)

A proposal for implementing current BIM practices in connection to the H&S issues found on the building sites.

With a focus on models and digitization I would like whenever you have an object in the model, it can have a flag around it and show the safety issues when you have to mount it. (47)

A proposal for using BIM to educate and prevent workers from taking risks.

Because we use Dalux and we have a good BIM viewer, then all of them (workers,subcontractors) built the building from BIM and digital drawings. So if you use the model to highlight these things (to indicate the risks) it will reach even the "superman" (referring to the workers that risks on purpose) in the end.... (48)

Migrant Workers

When asked about if there are migrant workers actually working on the building sites and what is done differently in regards with the presence of migrant workers at the workplace, the interviewee 1 said that they have only 1 Polish worker that speaks well English:

The only difference is to speak English with him instead of Danish... (49)

Sometimes there are communication issues with migrant workers, as mentioned by the interviewee 2:

We also have some foreign workers and that can be a communication issue, we have the handbook in many languages... But I think there are really small things: a little bit culture, a little bit communication and I know that this is an issue in general in the industry. (50)

According to interviewee 2, there is evidence that there are issues that need to be improved:

We have a big focus on that, the government, the unions and everybody has a huge focus on migrant workers. We haven't seen that on our site a lot. (51)

An example of communication via employment bureau stated by the interviewee 2 regarding migrant workers:

We have people from Lithuania that are not speaking a word of Danish nor English and the communication is held through the company that they work for. (52)

Potential risks that can be avoided are caused by migrant workers. The following quote from the interview with the interviewee 2 can support the claim above:

There is a bit of a culture issue. I don't know if it is because they come from a culture that they are more pressured and you have to be on your own and help yourself. Therefore sometime I think they solve the problem when they see it. When installing elevator there was a 40 meters height (shaft) and if you fall you are done. We had one of them (migrant worker) who was standing on the top of the railing to reach something... It was only one person doing the wrong thing. (53)

A case is presented about a migrant worker that is increasing intentionally the risk to make his job easier as seen in the statement provided by interviewee 2:

I think this is not something that we can prevent by talking more, because he (migrant worker) knows it's wrong... He just know that it's easier if you do it like this. (54)

COVID-19

When asked about the H&S measures taken during on the outbreak on the building sites, the interviewee 1 said that:

Hygiene is priority... small teams... some workers also have to be tested for COVID-19 before going on some sites abroad... Some workers had to stay abroad during Easter... when working in Norway, due to safety measures on the outbreak... (55)

During the lockdown of the society, the company where the interviewee 1 works, was holding online meetings in order to comply with the guidelines given by the government about the spread of the infection, as seen:

...All meetings are held on MS Teams... (56)

A certain degree of digitization help the situation with COVID-19, according to the answer given by interviewee 2:

Digitization and online meeting kept the wheels going. (57)

COVID 19 affected also the construction sites, as the interviewee 2 said:

It has affected us as much as we fear it would. Some workers on site isolated themselves (for hygiene reasons). Only the first week there were problems and they would ask to go home, but we can't send them home, only their bosses can send you home if they think that you are in risk. (58)

5.2 Findings

In this section the summarised analysis of the qualitative interviews are used in order to verify the findings.

In this section, the major themes and sub-themes that emerged from the data will be outlined. The first step of the data analysis is the comparison of the raw data, from the content of each interview and identification of the most frequent terms shown across these interviews. See Table 5.1 on the facing page. The second step concerns the identification of the main concepts which were synthesised into themes and sub-themes in accordance with table 5.2 on the next page.

5.2.1 Codes and Themes

In table 5.1 on the facing page some quotes from the qualitative interview were taken in order to generate some codes. From the interview quotes the following codes were generated, namely: **safety attitude, effective communication, digitization, COVID-19, culture, communication among workers**. Then these codes were put in the first column of table 5.2 on the next page. Afterwards the themes that derived from the codes can be seen in the second column of table 5.2 on the facing page.

| Codes / Statements | |
|---------------------------------|--|
| Safety attitude | <i>When people are lazy and don't want to use the right tools and just take a ladder, climb up and do their own things because they have good balance. That is again the "superman theory", he can fly so he can do that himself, and there is no tolerance on that.</i> |
| Safety attitude | <i>...Even if we did everything, inform everything, given all the equipment, in the end it is up to the person who has to do the task and wear the equipment to decide if they are going to do that normally, if they are going to do something different, not use the equipment as it should...so, the main challenge is ...the person who will do the task will decide if they will do what they should or if what they are doing is safe enough or if they will take a risk...</i> |
| Safety attitude | <i>There is zero tolerance strategy around people like those (people who don't follow the H&S rules)... If they can't obey (the safety rules), they have to go away.</i> |
| Safety attitude | <i>If someone refuses, then they can't be working on site...</i> |
| Effective Communication | <i>...The more we communicate, the more we can exchange communication and do the work well, not just in the safety perspective, but on the quality perspective too...</i> |
| Effective Communication | <i>Definitely communication is "big" in risk management both one on one and in general terms.</i> |
| Effective communication | <i>More communication is always better. Even though we think that only instructions are passed on and so on that we gave all the equipment..there are maybe things we forget.. To be sure that we say everything that could be useful...</i> |
| Digitization | <i>Digitization and online meeting kept the wheels going.</i> |
| Digitization | <i>... So if you use the model to highlight these things (to indicate the risks) it will reach even the "superman" (referring to the workers that risks on purpose) in the end....</i> |
| COVID-19 | <i>...All meetings are held on MS Teams...</i> |
| Safety culture | <i>If they are not using, the other workers need to remind it...</i> |
| Culture | <i>We have people from Lithuania that are not speaking a word of Danish nor English and the communication is held through the company that they work for.</i> |
| Culture, Safety attitude | <i>There is a bit of a culture issue. I don't know if it is because they come from a culture that they are more pressured and you have to be on your own and help yourself. Therefore sometime I think they solve the problem when they see it. When installing elevator there was a 40 meters height (shaft) and if you fall you are done. We had one of them (migrant worker) who was standing on the top of the railing to reach something... It was only one person doing the wrong thing.</i> |

Table 5.1. Codification and characteristics (Based on the qualitative interviews)

This findings are in line with the view that essential characteristics and drivers of safety amongst organizations are known as safety attitude. As shown in table 5.1, from the first 4 quotes, the extracted statements from the 2 interviewees corroborated with the code of safety attitude and Themes of safety participation, safety compliance and safety behaviour that can be found in the second column of table 5.2.

| Codes | Emerg ed themes |
|-----------------------------|---|
| Safety attitude | Safety behaviour, safety participation, safety compliance |
| Effective communication | Safety communication, effective communication |
| Digitization | Digital communication |
| COVID-19 | Digital communication |
| Culture | Cultural barriers |
| Communication among workers | Horizontal Communication |

Table 5.2. The themes and sub-themes that have emerged (Based on the qualitative interviews)

Here the emerged themes are: **safety behaviour, safety participation, safety compliance, effective communication, digital communication, horizontal communication and cultural barriers.**

Safety behaviour

According to the findings, the most used theme that emerged from the raw data collected from the qualitative interviews was safety attitude that corresponds to safety behaviour.

Safety behaviour can be considered as the actions that a person can adopt to prevent negative outcomes while maintaining a sense of safety.

Based on [Seo \(2005\)](#) some factors contribute to an unsafe work behavior. Factors like the perceived safety climate can reveal aspect like management commitment to safety, supervisor support, co-worker support and employee participation in safety. Another factor that can contribute to unsafe behaviour can be the perception level of the hazard. Some researches ([Rundmo \(1992\)](#) [Simonds and Shafai-Sahrai \(1977\)](#) [Tomas et al. \(1999\)](#)) proved a strong correlation between perceived level of hazard and the occurrence. This is not absolute though and unsafe behavior does not lead to accidents necessarily. Work pressure can be a factor that contributes to unsafe behavior. When the workload is excessive or there is time pressure it is more likely for accidents to happen and more unsafe behavior can be observed. ([Seo, 2005](#))

Safety attitude plays a major role in safety climate and safety behaviour. Based on [Mcgovern et al. \(2000\)](#) risky attitudes can be predicted from safety compliance. In addition, communication as part of safety climate can reveal aspects of safety behaviour ([Neal et al., 2000](#))([Mearns et al., 2003](#)). There are evidence to support that safety behaviour can also be affected by safety communication. ([Cigularov et al., 2010a](#))

As previously stated by the interviewee 2, a 100 days accident free bonus scheme is given to the construction crew. Bonus schemes can also lead to compromising safety in this specific case. As stated by [Collinson \(1999\)](#), bonus schemes can lead to the staff being pressured not to report an accident by the co-workers unwilling to miss the bonus. By doing so, the co-workers can become hostile to who report the onsite accidents.

The reinforcement of safety behaviour can be provided through praises from the supervisor. ([Chhokar, 1987](#))

Safety behaviour is divided in 2 types of behaviour as explained by [Neal and Griffin \(2002\)](#) namely safety participation and safety compliance.

Safety participation

[Vroom and Jago \(1988\)](#) suggest that participation is to take part. Thus, the participation can occur in a multitude of different forms such as: formal or informal, direct or indirect, shared or done alone.

The term safety participation is defined by [Neal and Griffin \(2002\)](#) as:

"behaviours that do not directly contribute to an individual's personal safety, but which do help to develop an environment that supports safety". (59)

The above mentioned behaviours that suggest safety participation activity are: taking part in voluntary safety activities, helping the co-workers with safety-related problems, and attending safety meetings. (Neal and Griffin, 2002)

In this research, safety participation is considered as all the activities that do not directly influence an individual's personal safety but do contribute to achieve an environment that supports safety.

The outcome from the findings suggest that safety participation is more often seen in the building industry.

Safety compliance

The term safety compliance is defined by Neal and Griffin (2002) as:

"the core activities that need to be carried out by individuals to maintain workplace safety". (60)

As stated by Neal and Griffin (2002), examples of safety compliance are complying with standard work procedures and wearing PPE.

However, Hayes et al. (1998) stated that workers who perceived their work as safe, complied with safety behaviors at the workplace often when compared to workers who perceived their work as lesser safe. This perception from the workers suggests that safety compliance is important for the organizations.

From the findings, safety compliance is still up to the worker since both project manager and foreman are not always available on the building sites.

Effective Communication

According to Vecchio-Sadus (2007), *clear and constructive safety communication provides the mechanism by which knowledge and understanding can be improved to prevent at-risk behaviours.*

Effective safety communication on building sites is essential in order to avoid hazard exposure and decrease the occurrence of injuries.(Cigularov et al., 2010b), (Albert and Hallowell, 2017) However, barriers to effective safety communication remain existing on the construction sites. Cigularov et al. (2010b), (Albert and Hallowell, 2017), (Alsamadani et al., 2013), (Allison and Kaminsky, 2017), (Chan et al., 2016) Unfortunately, these barriers can have an outcome of onsite incidents.(Cigularov et al., 2010b)

The building industry relies on information being exchanged among the different involved actors of a construction project, therefore, this communication must be effective. (Pozin et al., 2018)

Paraphrasing Pozin et al. (2018):

"Effective communication is becoming increasingly important in project construction because of the growing demands of the projects, along with the heavy amounts of technical work and the complexity of the supply chain process." (61)

From the findings, the communication on the building sites are verbal communication, one to one person or via radio/walkie-talkies.

Digital communication

Digital communication can be considered as the means of transmitting and receiving binary data. Internet is the mean that conveys all digital communication across the globe. (Heath and Salvekar, 2004)

According to IBM estimates in-person meetings cost up to 600 US dollars per hour, online meetings can decrease that cost to 6 US dollars. By using instant messaging and web conferencing the companies can eliminate travel expenses which can account up to 4 million dollars. Online meeting can be more shorter and more focused since they decrease the social interactions. Online meeting can provide automatic tracking of time and levels of participation, they can be recorded to be used later as material for sharing ideas and last they are adaptable to the quantity of the participants. (Green and Shepherd, 2011)

Dalux Field

With a use of software the need of having physical drawings is eliminated. There is the possibility of producing safety reports directly on a timely manner since the user can use his mobile phone/tablet app.

Thus, this software is used on the construction site that interviewee 2 supervises. Dalux is a software that displays 2D or 3D images on a device that is either portable (mobile phones, or tablets) or stationary(laptops or desktops). The images can be generated from a 3D model and they are stored on a server for subsequent retrieval and display on a device (Larsen, 2014)

With Dalux, the user can create safety reports while being present where the hazard occurs. Then the application can notify the people that are involved with the specific hazard. People can work either online or offline, since there is the possibility to update instantly the uploaded model file when the connection to internet will be reestablished. The users can view, manage or generate reports or dashboards for the specific construction project. (Dalux, 2020)

Horizontal communication

The definition of horizontal communication according to Health and Safety Executive (2005) is:

"the horizontal communication refers to information that flows between individuals at a similar level within the organisation, or between departments or functional units". (62)

This communication involves informing the crew about potential H&S risks at the workplace.

(Lundgren and McMakin, 2018)

Edmondson (1999) concluded that learning behavior mediates between team psychological safety and team performance which suggests that it is important for the workers to create structures and beliefs within a team in order to attain a positive safety behaviour.

In accordance with Laughery (2006), warnings is considered as safety communication intended to give information about safety-related issues.

Normally, the communication moves vertically within organizations, but Simpson (1959) found that horizontal communication which is the communication among the workers, depends on the level of mechanization.

In the findings, if the workers need a reminder on PPE, it is noticed that the co-workers are the ones helping on giving reminders on safety communication towards safety compliance.

Cultural barriers

Mehra (2003) stated that cultural barriers is one of the communication barriers which is identified by differences in ethnic, religious and social status.

Kartam et al. (2000) argued that different labour cultures, traditions and work habits of the migrant workers affect safety. This is corroborated by field studies that have shown that language affects the safety at the workplace. (Lindhout et al., 2012)

Thus, Ngowi (2000) stated that the problem that comes from the fragmented nature of the construction industry during the design phase is amplified by the language differences or by the communicating culture of the staff.

Thus, differences in culture, gender and language proficiency are recognised in the literature review chapter, in section 3.9.1 on page 49 as systemic barriers to effective safety communication in the construction industry, especially on the building sites.

According to the findings, if the construction crew do not master the same language of the workplace, translation of the safety rules and communication via their employment agency are done in order to safeguard the safety regulations.

Discussion

The purpose of this chapter is how existing reviewed literature concerning safety communication could be implemented throughout the construction industry. The following discussion takes offset on the information given in the qualitative interviews by the interviewees. The purpose of the suggestions presented in this chapter is therefore to be used on the building sites during the execution phase.

In the current research is examined if safety communication on the building sites affects safety behavior in terms of onsite H&S. In addition, explored is whether the communication aspects of safety have an influence on safety behavior.

Based on the reviewed literature, interviews were conducted as shown in the data analysis chapter, section 5.1.2 on page 61, in order to see whether there is a relation between safety and communication aspects regarding safety on the building sites.

As previously discussed in the introduction chapter, in section 1.2 on page 2, poor safety communication is a common work related problem and a very known issue in the building industry.

Bridging safety communication with safety behaviour

It is a widespread in the literature that if safety hazards are not properly communicated, the likelihood of occurrence of onsite injuries due to hazard exposure increases.

Likewise, many researchers have demonstrated that effective safety communication engages staff into sharing relevant information about safety which promoted good safety behaviours like for instance: safety compliance, safety participation and hazard recognition. (Albert and Hallowell, 2017), (Griffin and Neal, 2000), (Cigularov et al., 2010b), (Probst, 2004).

However differences in culture, gender and language proficiency are recognised in the literature as seen in section 3.9.1 on page 49 as systemic barriers to effective safety communication in the construction industry, especially on the building sites.

6.1 Key points from the data analysis put into the literature perspective

6.1.1 Improved safety communication

Communication is a term seen by many authors as a factor of safety climate that influences safety behavior. (Lu and Yang, 2011), (Fernández-Muñiz et al., 2012)

In the current research, the main focus is onto safety communication.

Safety communication is important for assuring that regulations, rules and instructions are followed as they should by the construction crew, and at the same time, that the likelihood of the occurrence of situations where workers are at risk is minimized or mitigated on the building sites.

- *...More communication is always better. Even though we think that only instructions are passed on and so on that we gave all the equipment..there are maybe things we forget.. To be sure that we say everything that could be useful...*

As previously discussed in the findings under the section 5.2 on page 68, it is confirmed that safety communication is one of the attributes that can affect safety on site. It was one of the codes that was generated by the interview quotes and it could be detected by the research team.

The adoption of clear and constructive safety communication as shown in the literature review, in section 3.9.1 on page 49 is an way to improve safety communication on the building sites. This statement is supported from both the findings and the literature review.

6.1.2 Improved safety compliance

The safety compliance is known as the activities performed by the workers in order to keep a safe workplace, like for instance, the correct use of PPE and the obedience towards the work procedure as stated in the data analysis chapter, in subsection 5.2.1 on page 71 .

It is observed in studies that when a worker perceive his job as safe, he tends to comply with safety behaviors at the workplace.

As the statement below found in the findings:

- *Even if we did everything, inform everything, given all the equipment, in the end it is up to the person who has to do the task and wear the equipment to decide if they are going to do that normally, if they are going to do something different, not use the equipment as it should...so, the main challenge is ...the person who will do the task will decide if they will do what they should or if what they are doing is safe enough or if they will take a risk...*

Safety compliance emerged as a term in this report in the findings, in the section 5.2 on page 68. It was suggested as a theme in the thematic analysis by the code safety attitude.

It is needless to say that safety compliance should be embedded in the mindset of the workers because a supervisor cannot be always present on the building sites. When the supervisor is absent, the weight falls into the employee's hands in order to comply with onsite H&S rules.

6.1.3 Improved digitalization

Construction design implies a set of communication and interaction skills between workers and groups in complex social settings. Therefore, *the social character of design activity cannot be separated from the technical results.* (Minneman, 1991)

The collaboration using ICT tools in the building industry has been intensified by increased globalization and virtual teamwork. (Sherratt et al., 2010)

From the results of the data analysis it is clear that BIM tools are known by the management

team and used in a great extent in the building industry.

- *...We design all projects in 3D... By planning everything very well with BIM tools, it does not require imagination... people can see how it looks like, so we avoid uncertainties as much as we can, and therefore avoid “bad solutions” onsite... Difficulties are known ahead, and can be solved safely.*

There are available a lot of options about digital tools for management of the building sites. As shown before, Dalux Field has a safety feature in its platform, however is up to each individual organisation to use the digital tools that meet their needs concerning their expertise and experience on the building sites.

As exposed previously in the findings, not all companies use the same digital tools. One company uses Dalux which has a safety feature interface for building sites. The other company does not use a digital tool for implementing safety or producing any safety reports.

According to the findings, a desirable hazard recognition on building sites is lacking in the industry from the BIM models, as well the proper identification of the onsite safety risks in the BIM models already from a very early stage. This is noticeable by the following statement, as seen on 5.2 on page 68:

- *With a focus on models and digitization I would like whenever you have an object in the model, it can have a flag around it and show the safety issues when you have to mount it.*

So, in other words, an implementation of the BIM models in regards with safety on the building sites is a way to improve safety through digitalization.

6.2 Proposed solution and recommendations

The proposed solution and overall recommendations found in this section come from the findings from the data analysis that are further discussed in section 6.1.

In order to secure the further implementation of safety on the building sites, a possible solution is the adoption of a safety flowchart within the organisation for the management of safety communication on the construction site.

Based on the patterns that emerged from the interviews and the literature review, it is possible to say that the organisation in the construction industry can benefit from the adoption of such tool.

The research team decided that a flow chart diagram with processes can provide a framework for better implementation of the H&S on site. A flowchart diagram can define and visualize the processes while analyzing them at the same time. The online tool lucidchart was used for this purpose and it can be seen in figure 6.1 on the following page.

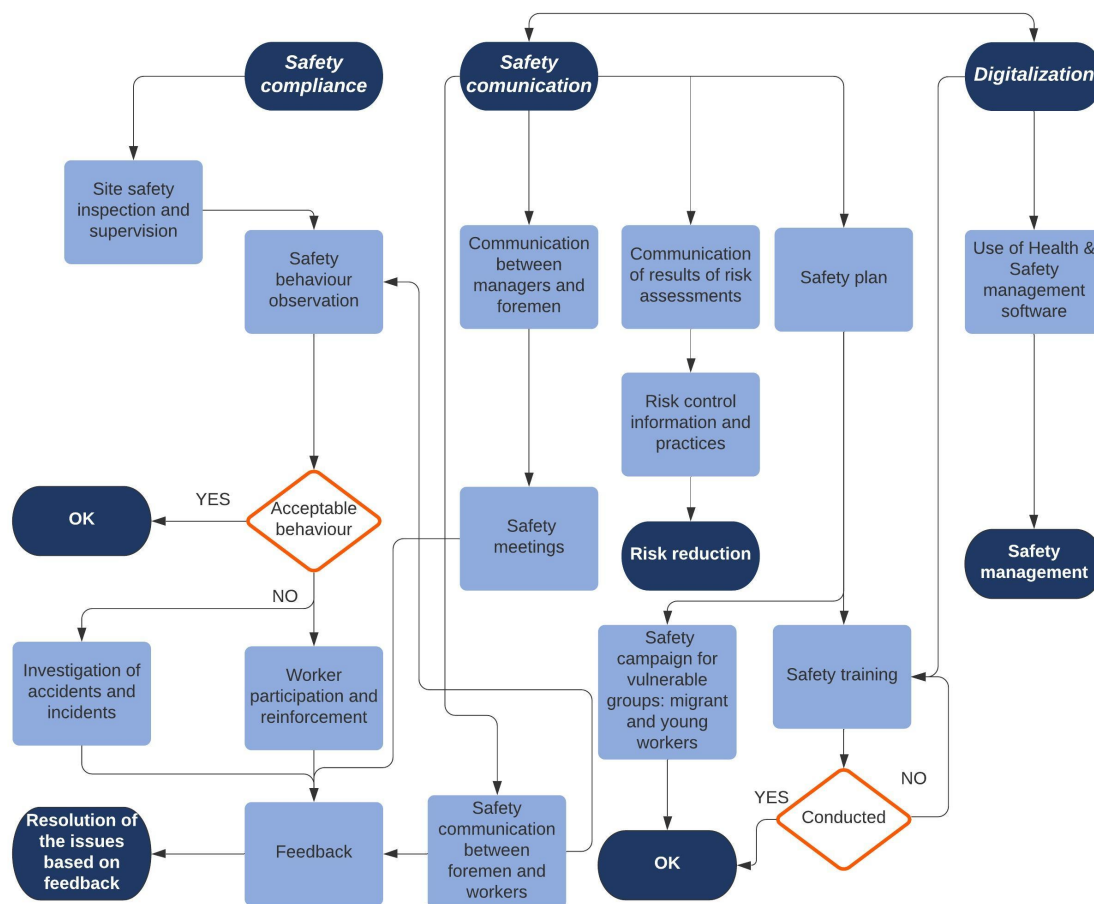


Figure 6.1. Construction safety flowchart

From the findings, it became clear that construction safety on the building sites is linked with three factors, namely: safety compliance, safety communication and digitalization which can significantly contribute to safety on the building sites. Therefore, the proposed solution called **construction safety flowchart** is illustrated and it starts with these three aspects as seen in figure 6.1.

Safety compliance can be revealed by inspections on the site and further observations of safety behaviours together with the number and type of incidents reported onsite. This gathered information can unveil if safety behaviour is adopted by the construction crew and how they evaluate H&S risks. The observation of the behaviour involves randomly sampling worker behaviour like for instance manual handling and the use of PPE. If the construction crew complies with the H&S rules, there is further observed an increase in safety behaviour which leads to desirable results in safety compliance. Otherwise, the managers or foremen can take initiatives such as worker participation during meetings and briefings about onsite safety. In fact, there should be *active worker participation* in risk identification, risk assessment, suggestion of control measures, as well worker participation in providing feedback.

Another aspect that can contribute on increased safety behaviour is the investigation of accidents. Therefore, constructive feedback derived from the investigation of accidents or from the worker participation which can improve safety on site is indeed relevant for the sought improvement of

safety on the building sites. Consequently, the managers or foremen can resolve issues based on this feedback. Feedback has been discussed in 3.9.2 on page 52. The use of constructive feedback and the reinforcement of safe behaviours through praises given to the workers by the foremen or managers increase the engagement of the staff onto safety behaviours such as safety participation and safety compliance at the workplace.

Safety communication is the second aspect that can affect positively safety on site. With proper communication between the involved actors on the construction sites can decrease the risks at the workplace and consequently the compensation for these accidents and incidents.

The effective and constructive communication between foremen and workers has been shown to have a strong influence on safety behaviour and can result in constructive feedback, this statement has been further researched under the section 3.9.1 on page 49.

Regarding safety communication, it is possible to say that providing information about the results of the risk assessments and risk control to the workers can decrease risky situations, as seen in section 3.5.1 on page 31 and consequently improve safety on the building site. It is obvious that good safety communication is related to the involvement and participation of the workers in H&S actions in order to increase personal safety and to prevent accidents.

Moreover, a safety plan should be taken seriously and be custom made for each specific building site. A recurrent tendency in the building industry is to make use of templates as mentioned in the findings, section 5.2 on page 68. Regular safety training should be made a priority especially for vulnerable groups of workers such as migrant workers, as seen in section 3.9.3 on page 55 and young professionals. The safety campaigns should always help the crew to obtain basic knowledge in safety at the workplace and not stigmatise the vulnerable groups of workers. It is of great importance that safety training should be repeated whenever needed based on the frequency accident occurrence.

From the findings, in section 5.2 on page 68, **digitalization** is shown to improve greatly safety on site, thus this aspect has great potentials to offer on the building sites in terms of safety management. Digitalization can also help in areas such as safety training with virtual reality or augmented reality programs. Finally, the use of H&S software can add value to safety management by reducing significantly the risks on the building sites with the use of virtual models or safety tools. The use of digitalization and digital tools for communication within the building industry are taken as a necessity especially now during the pandemic caused by the COVID-19 outbreak. Companies need to adapt to the currently imposed measures of social distance at the workplace in order to survive and still operate in the market.

Checklists for complying with the framework based on the construction safety flowchart

As seen in figure 6.1 on the facing page, the construction safety flowchart is illustrated and created based on the 3 pillars that emerged from the findings presented in chapter 5.

However, digitalization is further linked to safety communication, therefore the 2 pillars that are serving as basis for the safety implementation on the building sites and consequently, development of a construction safety checklist are namely, *safety communication* and *safety compliance*.

| Processes | Yes | No | N/A | Comments |
|---|--------------------------|--------------------------|--------------------------|----------|
| 1. Custom made safety plan for the building site | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 2. Communication of results of risk assessments | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 3. Risk control information | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 4. Safety trainings based on the results of the risk assessment | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 5. Safety campaigns for vulnerable groups of workers | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 6. Regular safety meetings or safety briefings | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 7. Clear goals for onsite safety | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 8. Daily onsite safety dialogues between foreman and workers | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |

Figure 6.2. Checklist for safety communication

As seen on figure 6.2, the first step of the checklist is to make a safety plan for the specific site. It should be customized and not a template. Then the next step is to focus on the results of the risk assessments. This information needs to be communicated to the relevant workers.

Then this information has to generate a safety training plan based on the the risk assessment results and risk controls.

Risk controls can help managers make decisions that can minimize the risks and ensure that the risks are monitored and kept at tolerable levels. Additional measures, like for example, the safety campaigns for the vulnerable groups such as migrant workers or young professionals can supplement the safety training done previously. Consequently, regular safety meetings or briefings can help to update the construction workers in new hazards and inform about the already identified ones. Another measure that can supplement safety communication is to set targets for safety on the particular building site depending upon the safety plan. Finally, the foremen should keep the communication channels open and speak daily with the crew on safety matters and hazard avoidance.

From the figure 6.3, there are 8 steps that must be followed from the checklist based on safety compliance.

| Processes | Yes | No | N/A | Comments |
|--|--------------------------|--------------------------|--------------------------|----------|
| 1. Safety site inspections | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 2. Regular Safety tours | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 3. Identification of hazards and risks through worker participation in meetings or briefings | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 4. Bring management and workers on board about onsite safety through motivation | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 5. Evaluation of incidents and accidents | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 6. Identification of risky behaviors through random observations of workers | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 7. Constructive and clear feedback | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 8. Recognition of the efforts and praises given | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |

Figure 6.3. Checklist for safety compliance

The first step is that site inspections based on onsite safety must be performed by the management team. In fact, the second step is that regular safety tours aiming onsite H&S must be performed by the management team or responsible manager. The third step is the identification of hazards and risks onsite by the participation of the workers during meetings or briefings. It is important to evaluate the accident data collections and the reports in order to learn from these accidents, near misses and incidents. The result from this evaluation is further discussed during the safety meetings if actual otherwise, it is discussed during meeting and briefings where safety in general is in focus. The next step is the randomly observation of the safety behaviours and the identification of the risky behaviours, by doing so, there is a change that through motivation, that the workers that were acting negligent or careless during work, become aware of the risks and begin working in a safe manner. The following step is clear and constructive feedback with the worker participation. The blame culture is avoided, instead motivation and positive feedback is given. The last step is praises given to the safe actions and the recognition of the workers' effort in the change of behaviour towards safety on the building site.

Overall recommendations for the construction industry

A recommendation is to improve the basic knowledge about construction safety to the construction crew.

Another recommendation is that companies develop themselves further as a learning organisation by investing in *learning safety culture* where it is possible to learn the lessons through previous accidents, near misses and the analysis of observations about non-compliant behaviours of the crew.

Another recommendation is that the collective bonus scheme for rewarding zero accidents on the building sites is not used, since it can lead the employees to not report incidents and accidents and by doing so, it can compromise onsite safety.

Conclusion

In this chapter, the conclusion of this master's thesis is presented. The conclusion will include a general conclusion of the whole report and won't expand further into notions. This chapter includes also some suggestion on further studies that the research team didn't elaborate on.

The adoption of safety management standards such as ISO 45001:2018 can result in decreased of unsafe behaviour and consequently less accidents. The communication aspect on ISO 45001:2018 can be seen in the part of worker participation. When engaging workers in the safety processes feedback is generated so the hazards occurring can be minimized and at the same time the workers have a sense of being part of the process.

7.1 Conclusion based on the problem statement

At the end of Chapter 4, Problem formulation, the following problem statement was proposed:

How can safety communication among the involved actors on the building sites be improved during the execution phase?

It is during the execution phase that the fatal accidents and incidents occur based on decisions taken in the design stage. So, it is important to bear in mind that during the design phase, safety should be in focus in order to prevent and mitigate the occurrence of injuries and fatal accidents on the building sites. Due to the temporary nature of the construction project, there are different actors involved in the project during the execution phase on the building sites, therefore daily communication is extremely important in order to prevent injuries and to ensure safe and successful project execution. In fact, daily communication about safety is needed in order to give updates on the daily changes happening on the building site during the execution phase. As there are many different trades and various construction workers working at the same time on the construction site, it is paramount that information is shared daily about daily changes on the work activities, schedules, weather, hazards, new workers, visitors' presence and progress updates.

It is known the positive effect that safety communication has on the building sites including the use of safety training, safety weeks, safety posters, safety campaigns among vulnerable group of workers, as well the use of other channels of communication in order to share information about safety among all workers within the organisation, for instance, through newsletters, e-mail, intranet, boards etc.

Safety communication can be improved through daily communication between the foreman and the workers, including worker participation and feedback.

In order to enhance safety communication on the building site is paramount that the managers and the foremen are able to play the role of team players instead of leaders or supervisors, because the managers and foremen need to know enough about onsite safety and have the proper training in order to disseminate information about safe actions and safety behaviours.

The managers and foremen must be "effective" communicators meaning that they should be able to give messages about safety to the workers effectively.

Regular safety tours on site by the managers, as well regular safety meetings and safety briefings are needed to remain compliant with construction safety regulations and keep the construction staff safe on the building sites by keeping them updated about actual hazards and risks during the execution stage.

The proposed framework known as construction safety flowchart should be put into practice within the organisation, by doing so, the project manager can better communicate the importance of H&S with the foremen and the construction crew. The adoption of the safety construction checklist during the execution phase will ensure that safety communication and safety compliance are actively monitored by the management team. This action will ensure engagement among the staff through worker participation, cooperation and constructive feedback and at the same time, mitigate further at risky situations at the workplace.

Additionally, the overall findings suggest that investing in organizational safety culture and safety communication, especially horizontal communication, will lead to an improvement in safety behavior and consequently, in safety compliance, which means a significant reduction of accidents and injuries on the building sites. Once the notions of a good safety culture and safety climate become embedded within the organisation, adequate safety behaviour and consequently, desirable safety compliance will become part of the daily routine of the construction workers on the building site. This ideal scenario will take time, however the benefits of this implementation, through consistent, effective and daily safety communication, will remain over time.

Finally, the use of H&S software can improve safety management and simultaneously, can enhance communication of safety among the involved actors on the construction project.

Further studies

Further research is needed on the long term effects of COVID-19 exposure related to H&S risks on the building sites, due to the limited time frame of this study and the sudden outbreak of the infection.

Further studies on onsite safety communication, coaching and feedback for all involved actors in the building industry during the construction phase are recommended.



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Questions for the interviews

General questions:

- What is your education? How long have you worked in the industry?
- Which project are you working on at the moment?
- What part of the project are you responsible for?

Safety culture:

- Is the implementation of H&S rules the same at all construction sites?
- What practices do you use to implement the H&S rules?
- Do you have a formal line from your office to the site regarding safety?
- Is safety on the building site a top priority for everybody on site?
- Are safety meetings held every 2 weeks?

Existing practices in the building industry:

- What are the current practices in Health and safety on the building sites?

Safety communication:

- How does the communication between the different actors occur on the construction site?
- Do you think that communication contributes to a successful project? Why or why not?
- What is done if the cooperation among different trades or involved actors in the project is not working as it should? How can the cooperation be reestablished when it has not been working properly for a long period of time?
- How can onsite challenges be improved by communication?
- Does your company employ migrant workers? If yes which countries they come from? If they speak a common language? Are communication problems and how this affects H&S
- How can mutual trust be ensured and kept among actors?
- How is the communication about the hazards on the construction site done?

Safety management :

- What is your role regarding onsite health and safety?
- Does your company provide Risk Assessments?
- How do you investigate injuries? Is there any emergency meeting after an accident has occurred?
- Have you ever been involved or witnessed in a major accident while performing your task? If yes, please give comments.
- Is there available a health and safety plan before the commencement of the construction project?
- How the machinery and plants are being inspected? Is there a log for that process?
- What are the key challenges connected to health and safety management?
- Is there someone checking if the personal protective gear is used on site? What happens if a worker is not using them on site?
- Have the workers the proper safety training education on the building site?

- Is there someone responsible to monitor safety policies, and keep safety records?
- How the construction tools and equipment handled with care? Is the maintenance and tools and equipment used onsite in order?

BIM:

- Are you familiar with BIM tools?
- How BIM can improve health and safety on the building sites?
- What are the key challenges related to the use of BIM for Health and safety management?

COVID-19 outbreak:

- How has the pandemic of COVID-19 affected your company ?
- What kind of measures do you take for COVID-19? Are the measures done differently in the office and onsite?
- Has the workflow been disrupted from the outbreak?
- Have these measures, that you have being taken, been effective so far?

Migrant workers:

- Do you have migrant workers on site ?
- Is the communication held in English or their national language?
- Are there differences in safety communication for migrant workers than for native workers?

B

Interview Guide

Table B.1. In this table the interview guide for the qualitative interview is illustrated. The interview is done in English as written in the table.

| Reference | Reflection | Question |
|--|---|---|
| What does the theory say | We would like to know | How do we get to know it |
| General questions | | |
| Starting questions to warm the interviewee up. | The first questions are basic and simple for the interviewee as a person. | 1. What is your education? How long have you worked in the industry? |
| | | 2. Which project are you working on at the moment? and how old are you? |
| | | 3. What part of the project are you responsible for? |
| | | 4. What do you recognize as the major problem in the industry? |
| | | 5. what are the main factors for delays in the building industry? |
| Existing practices in the building industry | | |
| Starting questions to warm the interviewee up. | To gain knowledge about the current and best practices. | 6. What are the current practices in H&S on the building sites? |
| | | 7. What are the best practices currently used in H&S management? |
| Safety Communication | | |
| About direct and indirect messaging, verbal or written. | How the messages are communicated among the workers . | 8. How does the communication between the different actors occur on the construction site? |
| It will help to lead to the problem formulation. | Discover if there are problems in the current site. | 9.How can onsite challenges be improved by communication? |
| | Reveals issues that are crucial for communication . | 10. Can you refer any cases where communication has been crucial to the success of the project? |
| About direct and indirect messaging, verbal or written.. | Understand the external communication | 11. How do you communicate with external partners? |
| Continues on next page | | |

| Reference | Reflection | Question |
|---|--|---|
| What does the theory say | We would like to know | How do we get to know it |
| It will help lead to the problem formulation. | Reveal the communication and safety culture. | 12. Does your company provide any guidelines for how to communicate on a project? |
| | | 13. Is there a proper and prompt communication on safety issues? |
| Safety management & safety culture | | |
| Refers to RAs and emergency management plans. | Get information about RAs and the emergency plan | 14. Are you aware of your role in an emergency management plan? |
| | | 15. Does your company provide Risk Assessments ? |
| How feedback is working in the construction industry regarding safety . | Figure out if and how injuries are reported | 16. Have you ever been involved in a major accident while performing your task? If yes, please give comments. |
| | | 17. Are all injuries investigated? Are these findings informed to the construction staff in a post-meeting? |
| | Find out about the on site safety issues? | 18. Are the construction machinery handled with utmost care? |
| | Find out about H&S training ? | 19. Have the workers the proper safety training education on the building site? |
| 20. Is there someone responsible to monitor safety policies, and keep safety records? | | |
| If there are issues with understanding the rules and regulations | If specific measures for H&S are taken for migrant workers | 21. Do you have migrant workers on site ? |
| | | 22. Is the communication held in English or their national language? |
| | | 23. Are there differences in safety communication for migrant workers than for native workers? |
| Continues on next page | | |

| Reference | Reflection | Question |
|--|---|---|
| What does the theory say | We would like to know | How do we get to know it |
| Based on the theory of safety culture. | Helps understand if safety culture is part of the corporate culture and how behaviour affects it | 24. Is the implication of H&S rules the same at all construction sites? |
| | | 25. Do you have a formal line from your office to the site regarding safety? |
| | | 26. Is safety on the building site a top priority for everybody on site? |
| Based on the COVID-19 section. | Helps understand if the company's workflow is affected and also the overall consequences . | 27. How has the pandemic of COVID-19 affected your company ? |
| | | 28. Has the workflow been disrupted from the outbreak? |
| | Gives information if the companies have taken measures to ensure the security of the workers against COVID-19 . | 29. What kind of measures do you take for COVID-19? 30. Are the measures done differently in the office and onsite? 31. Have these measures, that you have been taken, been effective so far? |



Interview with Vincent Lykkegård-Maes

Interview made with Vincent Lykkegård-Maes, project manager in DS Stålkonstruktion A/S, in Hobro, North Jutland. (Field notes)

The following link leads to the interview audio: <https://drive.google.com/file/d/1Bkse9-qn2Nbe-JXgOIEeTqj3SSf0mmDR/view?usp=sharing>

General questions:

- What is your education? How long have you worked in the industry?
 - Civil Engineer, Management in the building industry. 4 years (without gap years and internships), 6,5 years with.
- Which projects are you working on at the moment?
 - Some hangars for the army, a factory, an extension of a supermarket.
- What part of the project are you responsible for?
 - Project manager - Economy and Delivery of the steel construction, and erect it. (includes make it calculated, drawn into production drawings, sent in production, delivered on site, and make sure everything goes as planned on site, and delivery. It includes of course as well the budgeting and management of subcontractors).

Safety culture:

- Is the implication of H&S rules the same at all construction sites?
 - Globally, we follow the same procedure for our part of the works...we only focus on the steel... But it is more concerning the interaction with the other companies and the site that is affected by this, not our job... It depends on the project, the client and developer. For example, the requirements from a client when we erect stable building for a farmer are not the same that when it is a medicinal factory.
- What practices do you use to implement the H&S rules?
 - There are several things, we use of course the guidelines concerning how to use the tools, how to lift them, how to hang things with the cranes so on...onsite we have to follow the rules and the things that the Work inspection give but we have our foreman onsite that is coordinating the things, that makes sure that the things are made as they should. We do risk assessments but this is prior to our work onsite so we have for every project we make the plan for safety and it includes a risk assessment...But mainly, it is each erector that need to make sure they do things as they should and especially the foremen's role.
- Do you believe that all the accidents could be prevented?
 - No, I think there is always a factor that you cannot control, because it is not your responsibility. If an other company drops something above you, if a tool has a defect

piece, that you could not see... I don't believe that everything can be avoided, but that you can minimize as much as possible both the likelihood that it happens, if you do a good maintenance on the tools and all the checks that are necessary and so on. (lower the likelihood) Also if you follow the rules of how to use and of how to protect yourself, you lower the consequences...if people believe that could be always avoided than it would be not need of protection because it wouldn't happen so I believe that happens, but you can make it as not a big deal if you protect as well. But risks can be minimized as much as possible if all rules are respected, and consequences also minimized with personal protection equipment. Lower likelihood, if safety checks are done.

- Is safety on the building site a top priority for everybody on site?
 - I don't think it is top priority for everybody but I am not always on site so I cannot check what people do all the time. But sometimes when they are used to do something, it goes faster. Maybe there is a small risk but people access it as then it will go, you know, when you do things many many times, sometimes you just neglect a bit security because it went fine a thousand times, why shouldn't it go fine the 1001st time ?
- Are safety meetings held every 2 weeks?
 - Most of our project don't take two weeks to erect. But if the project is longer, there is a safety meeting held by the main contractor every second week, that our foremen that need to attend.

Existing practices in the building industry:

- What are the current practices in Health and safety on the building sites?
 - Making a "arbejdsplassvurdering" and risks analysis, Wearing the right equipment to each task, checking the machinery/equipment before use, using tools to what they are designed for.

Safety communication:

- How does the communication between the different actors occur on the construction site?
 - Technically: Orally, with or without radios. The foreman leads the team, plans with the project manager, and has the daily communication with other trades onsite.
- Do you think that communication contributes to a successful project? Why or why not?
 - Of course. It allows to find the potential problems, discuss them to find a solution and solve them. This concerns both technical problems, human tensions (human conflicts can start the safety problems, if people are arguing they are not focusing on what is going on security, people drop tools), logistic problems, planning and security. The more we communicate the more we can exchange communication and do the work well, not just in the safety perspective but on the quality perspective.
- What is done if the cooperation among different trades or involved actors in the project is not working as it should? How can the cooperation be reestablished when it has not been working properly for a long period of time?

This problem does not concern us that much. We are the first to arrive, just after the concrete team that is done). If the foreman cannot succeed with the communication, so he talks to the project manager and go up in the hierarchy, so a meeting will try to diffuse the problem more than a phone call. If problem is not solved by themselves, someone from the upper will make an arbitration.

- How can onsite challenges be improved by communication?
 - As we erect steel, we quite often arrive on site before most of other trades, and our intervention on site is often quite short. This problem does not concern us that much. Otherwise like the answer from the other question.
- How can mutual trust be ensured and kept among different actors?
 - In my opinion, trust is only achievable in the long term and after many projects with the same actors where everything has been good. All actors have their own interest, and even though trust is best for the general interest, in the end, it is always useful to have trace of everything, which is the proof that there is no real trust in the business world. For safety, it is in the interest of nobody to hurt no one around or be hurt by others. Show the others that they are working as they should or that they are holding what they said.
- Does your company provide any guidelines for how to communicate on a project?
 - Yes, I think it is like this on all projects. Not just on specific. Plan for safety, find the hazards and solve beforehand. Risk analysis. Safety meetings prior to the start of the work. Not written guidelines, it is a part of the job as project manager.
- How is the communication about the hazards on the construction site done?
 - Communication about hazards is done by startup meeting on site and with the crew, reading the PSS, making and submitting and discussing the APV and risk assessment before start of works onsite. Then, safety meetings every second week on longer projects.

Safety management :

- What is your role regarding onsite health and safety?
 - Making sure that our teams have all they need to work safely, provide the risk assessment and inform them of possible risks or instruction I would receive from the client.
- Does your company provide Risk Assessments?
 - Yes.
- How do you investigate injuries? Is there any emergency meeting after an accident has occurred?
 - I actually don't know, This is dealt directly by the erection department.
- Have you ever been involved or witnessed in a major accident while performing your task? If yes, please give comments.
 - I actually don't know... it has not happened on my projects.
- Is there available a health and safety plan before the commencement of the construction project?
 - Yes, there is.
- What are the key challenges connected to health and safety management?
 - More communication is always better. To be sure that we say everything that is useful. Training- make people understand the risk and the consequences they could have. The key challenges In the end it is always the free will of the worker at the moment of the action that can make an accident happen or not happen. It is also a challenge to make sure hat the work is understood, he instructions for safety are understood.
- Is there someone checking if the personal protective gear is used on site? What happens if a worker is not using them on site?

- It is each and every workers responsibility. The responsibility is to make sure that even though all instructions are passed on, equipment is OK and so on, the workers do as they are supposed to. If they are not using, the other workers need to remind it. If someone refuses, then they can't be working on site. It has not happened as I know of.
- Have the workers the proper safety training education on the building site?
 - Yes they have. They have training for new equipment once in a while, some sites requires also a specific training for that project. They erect the steel but they are also welders. They know the safety rules and training for new equipment and the equipment they use mostly as a reminder. Courses specially for lifts and elevation lifts.
- Is there someone responsible to monitor safety policies, and keep safety records?
 - Foremen are responsible for monitoring safety policies. Also project managers is they are on site. But no records as I know of.
- How the construction tools and equipment handled with care? Is the maintenance and tools and equipment used onsite in order?
 - Yes, things are sent to reparation if it is needed. tools and equipment are handled with care. The workers we have are all trained, they know their equipment, and have only interest in things working properly. They have enough gear, to be able to put aside what is not okay, and get things fixed by supplier when it needs to be fixed. Else they get new gear.

BIM:

- Are you familiar with BIM tools?
 - Yes we are.
- How BIM can improve health and safety on the building sites?
 - Yes it does. We design all projects in 3D. By planning everything very well with BIM tools, it does not require imagination, people can see how it looks so we avoid uncertainties as much as we can, and therefore avoid "bad solutions" onsite. Difficulties are known ahead, and can be solved safely.
- What are the key challenges related to the use of BIM for Health and safety management?
 - Making sure that everything is seen and treated ahead. See things ahead to avoid the problems.

COVID-19 outbreak:

- How has the pandemic of COVID-19 affected your company?
 - Change in organization we could not be all together in the same place, logistic difficulties to get steel (from Italy, Spain, France), increase in steel prices, difficulties to get workers on sites abroad...And big decrease in commands from clients leading to layoffs...
- What kind of measures do you take for COVID-19? Are the measures done differently in the office and onsite?
 - Most of people based at the office had to work from home. Before that, cleaning had been increased, break time had been changed to avoid too much contact between people. All meetings are held on MS Teams, going physically in other departments is forbidden. Yes, measures onsite are different. Hygiene is priority, small teams, some workers also have to be tested for COVID-19 before going on some sites abroad. Some workers had to stay abroad during Easter when working in Norway due to safety measures on the outbreak.

- Has the workflow been disrupted from the outbreak?
 - Yes it definitely has. Not getting materials on time, not being able to send workers in some countries, disrupted the workflow.
- Have these measures, that you have being taken, been effective so far?
 - Yes, to the max. extend, nobody got the disease. But they do not guard against things that are external factors.

Migrant workers:

- Do you have migrant workers on site ?
 - Yes, a few. Only 1 Polish working onsite that speaks good English.
- Is the communication held in English or their national language?
 - Onsite, 1 Polish that speaks good English, not Danish. In the factory, Polish and Romanians all the instructions translated into their language.
- Are there differences in safety communication for migrant workers than for native workers?
 - The only difference is to speak English with him instead of Danish. I don't know in the production if there is another procedure about the communication.



Interview with Mia Rosengaard Hansen

Mia Rosengaard Hansen, ICT/BIM-coordinator at the Project Department in the new Aalborg University Hospital, in Aalborg, North Jutland. (Field notes)

The following link leads to the interview audio:

<https://drive.google.com/file/d/1BmOjywXq7TB9uw9cnwe3ymu83VPeiPCk/view?usp=sharing>

General questions:

- What is your education? How long have you worked in the industry?
-Graduated in Architecture 2011
She has been working for Region North Jutland for almost 8 years.
- Which project are you working on at the moment?
-At Aalborg University Hospital from 2012
- What part of the project are you responsible for?
-3D modeling, digitization, ICT models, how to plan models

Safety culture:

- Is the implementation of H&S rules the same at all construction sites?
-3.30 Implementation of H&S rules is the same over all construction sites. On larger sites there are greater risks. This should be the managers' top priority.
- What practices do you use to implement the H&S rules?
-Use of handbook, 2 hour mandatory course, PSS mandatory for security (The security chief takes tours checks).
- Do you have a formal line from your office to the site regarding safety?
-We don't build the hospital for the construction site (workers) but for the society. We don't want the workers to be patients because of the job that they had.
- Is safety on the building site a top priority for everybody on site?
-Yes it is. All the subcontractor entrepreneurs are very responsible. Disobedient people are discarded. 10.30 Foreign workers have communication issues. We have the handbook in different languages. There are workers from Poland. Culture communication issue.
- Are safety meetings held every 2 weeks?
-11.52 Safety meeting every 2 weeks, ICT, (use Dalux) for more transparency.

Existing practices in the building industry

- What are the current practices in Health and safety on the building sites?
Indirectly answered by the previous questions. There is a physician for sore body parts.

Safety communication

- How does the communication between the different actors occur on the construction site?
-Verbal one to one, Walkie-talkie for cranes. Areas are separated by trade.
- Do you think that communication contributes to a successful project? Why or why not?
-17.00 Definitely communication is big in risk management. Communication one to one. Managers arrange work for the workers to be safe.
- What is done if the cooperation among different trades or involved actors in the project is not working as it should? How can the cooperation be reestablished when it has not been working properly for a long period of time?
-20.00 The biggest issue they have is that the architects have to design in a good manner. Architects, managers and entrepreneurs must have a good cooperation between them.
- How can onsite challenges be improved by communication?
-22.20 The architects, entrepreneurs and consultants go there and try to solve it. Not by the desk, but on site only. Example of use of leader instead of proper equipment. The superman theory (they have no tolerance).
- Does your company employ migrant workers? If yes, which countries do they come from? If they speak a common language? Are communication problems and how this affects H&S?
-23.30 The government and Unions have a big focus on that. There was an elevator company with people from Lithuania. There was no common language. They had to talk to the entrepreneur (subcontractor). There is a culture issue (superman issue). He climbed to reach something. They can't prevent it by talking more about it. The worker knows it's wrong but it's easier for him.
- How can mutual trust be ensured and kept among actors?
- How is the communication about the hazards on the construction site done?

Safety management:

- What is your role regarding onsite health and safety?
- Does your company provide Risk Assessments? -Risk assessments are provided by the entrepreneurs (subcontractors)
- How do you investigate injuries? Is there any emergency meeting after an accident has occurred?
30.00 Feedback. This is on the contractor. There is on the contractor. There is a whole department in big companies for H&S. People on site don't tell everything because of bureaucracy. They have to talk to people. It is like a mother conversation. Some of the people are paid for how fast they do their job and some with a salary, others by the hour, so they don't want to give feedback and work instead. This is an issue. Time is money. Some companies have the accident free 100 days and they give bonuses. What if you get hurt the 99th the day. Will you say it. Will you stop the bonus for the rest of your team. Who is gonna get the biggest band aid. Why should people have a bonus for doing their job properly.
- Have you ever been involved or witnessed in a major accident while performing your task? If yes, please give comments.
-34.37 Heart attack incident. There was a psychologist who gave help for the people that gave CPR. They make sure that everyone will get proper treatment.

- Is there available a health and safety plan before the commencement of the construction project?
 - 35.50 There are templates on H&S plans. Text mostly but she claims there should be more customization. Example: of a window in the ceiling. The people can put a flag on it in the model so other people could see. The workers could automatically be notified.
- How the machinery and plants are being inspected? Is there a log for that process?
 - 38.28 This is from the subcontractors.
- What are the key challenges connected to health and safety management?
 - 39.55 Time.
- Is there someone checking if the personal protective gear is used on site? What happens if a worker is not using them on site?
 - Off the site if someone drinks, 3 times on forgetting the helmet and she/he have consequences.
- Have the workers the proper safety training education on the building site?
 - 42.10 The workers take a two hour course from subcontractors.
- Is there someone responsible to monitor safety policies, and keep safety records?
 - 13.00 Construction manager 2 people the building site subcontractor how makes also inspections in the building area.
-

BIM:

- Are you familiar with BIM tools?
 - yes.
- How BIM can improve health and safety on the building sites?
 - 44.20 Merge the journals with the BIM model if you can attach to an object in the model.
 - She doesn't think that the people see the journals.
- What are the key challenges related to the use of BIM for Health and safety management?
 - 27.10 Everybody respects each other. There are no trust issues. There is always cleaning to be done though.

COVID-19 outbreak

:

- How has the pandemic of COVID-19 affected your company?
 - 17.00 In the beginning they were very worried, but they found a solution, digitalization, such as Skype or Teams (Microsoft). Everything stayed the same; the workers stayed isolated. They only had problems the first with their job.

Final statement of the interviewee:

45.10 Dalux is adding value and is a good BIM viewer. There are not any physical drawings. There are only digital drawings. If you use the model the info will reach the superman in the end and he will know what the potential dangers are. You can retrieve the model in any device. Example: of the lobby ceiling window that nobody should work underneath. The element could be red so nobody should approach underneath. Instead of only putting signage. The BIM specialists should put the input.