Strengthening Early Warning Response in the Construction Sector

A Qualitative Study on Mechanisms Influencing the Response to Early Warning Signs in Dutch Construction Projects

MSc. Thesis

Joris Stolk

December 2021

TU Delft

bam

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By

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in partial fulfilment of the requirements for the degree of

Master of Science

in Construction Management and Engineering,

Faculty of Civil Engineering and Geosciences,

at the Delft University of Technology

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Preface

Conducting this research on Early Warning signs, from their identification until they are responded to, gave me new insights into the topic's scope, but also outside this topic into the broad field of construction projects.

I would like to thank BAM Infra for allowing me to conduct this research at their organisation, especially my company supervisor Ir. Bas van de Weijer for giving me the opportunity to research this topic in a fascinating environment, guiding me through the organisation, and helping me find interesting leads and directions in the research. I want to thank everyone at BAM who participated in my research, either as interviewee, or by showing interest and sharing their vision on the topic in general. The welcoming atmosphere in the organisation made gathering information an enjoyment.

This research would not have been possible without the academic inputs, directions, and encouragement from Dr.ir. Bosch-Rekveldt, Ir. Koolwijk, and Prof.dr. Bakker. I want to thank them for being part of my TU Delft committee, and for giving me new insights in how research should be conducted.

Finally, I want to thank my parents, sister, and friends who have been a great source of motivation and energy throughout the thesis research and during the master's program as a whole.

Summary

Construction projects have become more complex over time, and cost overruns and time delays have become a global phenomenon. The complexity of projects continues to be underestimated, while costs of project failure in the construction sector are significant. Signs that can indicate future project failure, such as cost overruns and time delays, in early project phases are Early Warning (EW) signs. EW signs are defined as indicators for potential future problems. An EW sign does not contain information on when a failure can occur or how likely it is to occur. It does however act as a warning that should trigger a reaction to prevent the failure from becoming reality. Acting on potential problems early on in projects should give the project team more time to react or plan a future strategy, to reduce the impact of a potential problem on the project outcome.

To be able to anticipate the development of problems in projects, research has been done to describe the phenomenon of Early Warning. EW signs are gathered, response strategies are examined, and barriers for responding to EW signs are researched in literature. Literature focuses mostly on singular signs and an associated response, while the complexity of project environments seems to indicate that no event stands on its own. Previous in-depth research was conducted mostly exclusively from the perspective of the client in projects. This research provides a new perspective, by conducting research from the perspective of a contractor, including the interaction with sub-contractors.

To describe how reactions to EW signs are formed in construction projects, and to find underlying mechanisms that can potentially prevent reactions to an EW sign from taking place, the following research question was formulated:

> *How is the response to Early Warning signs in construction projects influenced?*

Four sub questions were defined to (1) create a theoretical framework of concepts from literature that are related to responding to EW signs in projects, (2) explore the influence of the construction organisation on the EW response on project level, (3) analyse how current responses to EW signs in practice take place, and how this process is influenced, and (4) to explore solution paths to mitigate found obstructions for responding to EW signs.

During the literature study, a new perspective was applied to current literature on EW signs: organisational behaviour theory. By distinguishing four levels of interaction that influence human behaviour, this theory aims to understand how behaviour is influenced. Literature focuses mostly on the project level, and especially the influence of the organisation level on the EW response seems underexposed.

Exploring how a construction organisation influences the response to EW signs, resulted in an overview of several aspects. Three interviews were conducted and the standard process of how projects are organised was analysed. The standard control mechanism, applied in projects, and general procedures regarding behaviour in projects, are not equipped to facilitate or stimulate identifying and responding to EW signs. This currently makes the construction organisation depend largely on individual experience, self-initiative, and knowledge of project personnel in projects to identify and respond to EW signs.

A qualitative case study research was conducted on three construction projects to explore examples of how the response to EW signs takes place in practice. For each case project, five interviews were conducted and documentation was gathered that contained information on how was acted in the

projects. Grounded theory coding and data analysis techniques were applied to the interview transcripts. Interviewees were selected using a snowball technique, whereby first the project manager was interviewed, after which each new interviewee was selected with the aim of getting closer to key players in the project that were part of the process of identifying and responding to EW signs.

Comparing the case events, and coded interview data from fifteen transcripts, two main mechanisms influencing the EW response were found. A third mechanism was found as a recurring theme impacting three out of four analysed EW responses.

(1) The lack of information flow in projects seems to prevent EW signs from being identified. Because the information system in projects is not organised to facilitate the identification and response to EW signs, data and early suspicions that could be used to identify EW signs, are lost or not accessible during the project. Especially at the transition from the tender phase to project execution, this information gets lost. Unaware personnel cannot respond to EW signs if they are not identified in the first place.
(2) Group culture and team interaction were found to hinder the response to EW signs in projects. After the identification of an EW sign, a response needs to be formulated in order to prevent or reduce the impact of a possible future problem. A group culture in which EW signs are not taken seriously, in which the collective idea is that problems will fix themselves, and in which a main focus is allocated to current timing and costs of a project rather than possible future problems for the project, prevent a response to an EW sign from being made. The focus on current costs and timing in a project seems to be driven by the emphasis of the project manager and the steering committee on these aspects. On an individual level, a lack of experience, and underestimating the impact of risks seems to affect the EW response as well.
(3) Interpretations of agreements and contracts, and trust in the work carried out by other parties seem to reduce the activity of identifying and responding to EW signs. Not feeling responsible to react to EW signs related to sections of a project that are contractually not the responsibility of the project team, according to their interpretation of agreements and contracts, was found to play a role in multiple cases.

Two experts from organisation level, and two experts from project level, reflected on directions for solutions that were presented to them in a group discussion. Attention for team composition, equipping the information system in projects with accessible options to store, access, and keep track of potential EW signs, increasing the attention to EW signs during the tender phase, and creating awareness of the importance of responding to EW signs, form the main directions for solutions to mitigate the obstructions found in this research.

The importance of the organisational level, and the lack of information flow in projects preventing EW signs from being identified, is the main new finding of this research. Conducting the research from a new perspective, the perspective of a contractor, may have contributed to this.

The findings from this research can be used by construction organisations to reflect on the ability to identify and respond to EW signs in projects. The four levels of organisational behaviour theory seem to help improve understanding of how people act and influence the EW response from multiple levels, and can be used to create insight in how policies can influence behaviour at each level as well. Further research is needed to find the specific functioning of the found mechanisms in multiple projects.

Samenvatting

Constructieprojecten zijn in de loop van de tijd steeds complexer geworden. Vertragingen en kostenoverschrijdingen in projecten zijn steeds meer een globaal fenomeen geworden. De complexiteit van projecten lijkt telkens te worden onderschat, terwijl de faalkosten voor projecten in de constructiesector significant zijn. Signalen die als indicatie kunnen dienen dat er in de toekomst projectfalen kan optreden zoals vertragingen en kostenoverschrijdingen, in vroege projectfasen, zijn Early Warning (EW) signs (vroegtijdige waarschuwingssignalen). Een EW signaal bevat geen informatie over het tijdstip van falen of over de kans dat het falen optreedt. Het signaal dient echter wel als waarschuwing en dient een reactieketen in gang te zetten om de impact van een toekomstig probleem te verkleinen, of erop in te spelen middels het formuleren van een strategie.

Om te kunnen anticiperen op de ontwikkeling van problemen in projecten is eerder onderzoek gedaan naar het fenomeen Early Warning. Signalen zijn hierbij verzameld, response strategieën zijn bestudeerd en barrières voor het reageren op EW signalen zijn onderzocht. Literatuur focust vooral op losstaande signalen, met losstaande responses, terwijl complexe projectomgevingen de indicatie geven dat meldingen zelden op zichzelf staan. Vorige onderzoeken zijn vooral uitgevoerd vanuit het perspectief van opdrachtgevers bij projecten. Dit onderzoek biedt vanuit een nieuw perspectief een beeld over het reageren op EW signalen, namelijk het perspectief van de aannemer in projecten. Hierbij is ook de interactie met onderaannemers meegenomen.

Om te beschrijven hoe het reageren op EW signalen tot stand komt in constructieprojecten en om onderliggende mechanismen te vinden die het reageren op EW signalen verhinderen, is de volgende onderzoeksvraag geformuleerd:

> *Hoe wordt het reageren op Early Warning signalen beïnvloed in constructieprojecten?*

Vier deelvragen zijn gedefinieerd om (1) een theoretisch raamwerk op te stellen met concepten uit de literatuur die gerelateerd zijn aan het reageren op EW signalen in projecten, (2) de invloed van de organisatie van de aannemer op de EW response in projecten te verkennen, (3) te analyseren hoe het reageren op EW signalen in de praktijk beïnvloed wordt, en (4) oplossingsrichtingen te verkennen waarmee eerder gevonden obstakels voor het reageren op EW signalen gemitigeerd kunnen worden.

Gedurende de literatuurstudie is een nieuw perspectief toegepast op bevindingen uit de huidige literatuur: ‘organisational behaviour theory’. Deze theorie heeft als doel om door middel van het onderscheiden van vier niveaus van interactie die menselijk gedrag kunnen beïnvloeden, te begrijpen hoe gedrag beïnvloed wordt. De onderscheiden niveaus zijn: de organisatie, het project, het team, en het individu. De huidige literatuur lijkt impliciet vooral te focussen op hoe vanuit projectniveau de EW response beïnvloed wordt. Vooral het organisatieniveau lijkt onderbelicht in de huidige literatuur.

De verkenning van de invloed van een aannemersorganisatie op het reageren op EW signalen in projecten resulteerde in een overzicht met meerdere gevonden aspecten. Hiervoor zijn drie interviews afgenomen en het standaard proces van projecten opzetten in projecten is geanalyseerd. Het standaard mechanisme voor projectcontrole en algemene procedures voor gedrag in projecten lijken niet uitgerust om het reageren op EW signalen in projecten te faciliteren. Dit maakt de huidige organisatie erg afhankelijk van individuele ervaring, zelfinitiatief, en kennis van projectpersoneel in projecten om EW signalen te identificeren en erop te reageren.

Een kwalitatief case study onderzoek is uitgevoerd bij drie constructieprojecten om voorbeelden van het reageren op EW signalen in de praktijk te verkennen. Bij elk case project zijn vijf interviews afgenomen. Ook zijn documenten verzameld over hoe gereageerd is in de projecten. Personeel werd geselecteerd door middel van een sneeuwbal techniek. Hierbij werd eerst de projectmanager geïnterviewd, waarna nieuwe respondenten benaderd werden met het doel dichter bij de reactie op het EW signaal te komen, gebaseerd op informatie uit het laatste interview.

Door de vier gebeurtenissen uit de drie case projecten te vergelijken, ondersteund met gecodeerde interviewdata uit vijftien transcripten vanuit een grounded theory methodologie, kwamen twee primaire mechanismen naar boven uit de analyse. Een derde terugkerend mechanisme werd gevonden bij drie van de vier cases. Deze mechanismen zijn:

(1) Een gebrek aan informatiestromen in projecten lijkt te voorkomen dat EW signalen geïdentificeerd worden. Informatiesystemen in projecten zijn niet georganiseerd om het identificeren van- en reageren op EW signalen te faciliteren. Hierdoor raakt informatie die hiervoor zou kunnen worden gebruikt, verloren of is niet vindbaar. Projectleden kunnen deze informatie lastig opslaan, bijhouden of doorgeven en missen hierdoor EW signalen. In het bijzonder de faseovergang van de tender fase naar de project uitvoer lijkt hier kwetsbaar.

(2) Groepscultuur en interactie binnen het team kwamen naar voren als hinderend voor het reageren op EW signalen in projecten, nadat een EW signaal in een project is geïdentificeerd. Een groepscultuur waarin EW signalen niet serieus genomen worden, waarin de collectieve gedachte is dat problemen zichzelf oplossen en waarin de focus ligt op huidige kosten- en tijdschema's in plaats van vooruit te kijken naar mogelijke problemen, verhinderd de EW response. De focus op huidige kosten- en tijdschema's lijkt gedreven door de nadruk die de manager en de stuurgroep hierop leggen. Op individueel niveau komt een gebrek aan ervaring met vergelijkbare situaties en het onderschatten van de impact van risico's naar voren als beperkend voor de EW response.

(3) Interpretaties van overeenkomsten en contracten, en vertrouwen in hoe andere partijen hun activiteiten uitvoeren lijken tot een afname in signaalherkenning en -reactie te leiden. Doordat men projectonderdelen die door andere partijen worden uitgevoerd minder controleert, of doordat men zich contractueel niet verantwoordelijk voelt voor bepaalde projectonderdelen volgens hun interpretatie van het contract of de overeenkomst, volgt een beperkte EW response.

Twee experts vanuit de aannemersorganisatie en twee experts opererend op projectniveau hebben in een expert meeting gereflecteerd op mogelijke oplossingsrichtingen om obstakels voor de EW response gevonden in dit onderzoek te mitigeren. Naar voren komen: aandacht voor de team-samenstelling in projecten, het informatiesysteem in projecten toegankelijker maken om EW gerelateerde informatie periodiek op te slaan op een vindbare manier, meer aandacht besteden aan EW signalen in de tenderfase, en bewustzijn creëren in teams over het belang van EW signalen.

De invloed die het organisatieniveau uitoefent op de EW response in projecten en het gebrek aan informatiestromen in projecten dat ervoor zorgt dat EW signalen niet geïdentificeerd worden, zijn de hoofdbevindingen die vanuit dit onderzoek nieuw naar boven komen. Dit kan komen doordat dit onderzoek vanuit een nieuw perspectief, het perspectief van de aannemer, uitgevoerd is.

De bevindingen uit dit onderzoek kunnen gebruikt worden door aannemers om te reflecteren op hun capaciteit om EW signalen te herkennen en erop te reageren. Organisational behaviour theory lijkt een bruikbaar extra begrip toe te voegen aan de huidige literatuur betreffende EW signalen. Vervolgonderzoek kan uitgevoerd worden om de specifieke werking van de gevonden mechanismen verder te onderzoeken in meerdere projecten.

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1 Introduction

This report presents the results of a MSc research regarding the response to Early Warning signs in construction projects. In the introduction chapter, first, the research context provides background information on practices that indicate the need for Early Warning signs in construction projects (Section 1.1). Next, gaps in current research towards understanding the response to Early Warning signs are discussed (Section 1.2), after which the goal of the research is formulated (Section 1.3). The research question and sub questions of this research are mentioned in Section 1.4 and finally, the structure of the report is explained (Section 1.5).

1.1 Research context

Construction projects have become more complex over time (Luo et al., 2017) and complex projects are more likely to fail (Luo et al., 2016). Failure of construction projects in terms of cost overruns and time delays are considered normal, and risks of scope changes, complexity and unexpected events continue to be underestimated (Flyvbjerg et al., 2009). Yearly costs of project failure in the construction sector in the Netherlands are estimated at 5 billion euro (Van Heel et al., 2019). These are the costs incurred to achieve the predefined specifications of the failed projects in the end.

Examples of project failure and poor project performance can be found everywhere, also in the Netherlands. The development of the Museumparkgarage in Rotterdam for instance was a project estimated at 100 million euros. A critical report afterwards mentioned that project complexity was underestimated, remarkably many personnel changes happened and risk analysis was neglected too much (Policy Research Corporation, 2007). The final costs of the project turned out to be double the amount estimated at the start. Could this not have been foreseen?

Another and larger project, the still ongoing Zuidasdok project in Amsterdam, also turns out to be more complex and risky than expected (Dekker, 2020). The cost overruns are already extensive and the scope of the project is extended multiple times due to fast changing needs on the demand side (infrastructure capacity for example). The report by Dekker (2020) emphasizes the lack of integral communication within the project team. The budget of the Zuidasdok project was set at 1.7 billion euros in 2015, while the estimated costs in 2020 are 2.6 billion euros (Programmaorganisatie Zuidasdok, 2021). Scope extensions and complexity are mentioned in the report as most important causes of this. The client (for the most part the Dutch government and the municipality of Amsterdam) was interested in reducing the final costs by means of austerity measures in the project plan, but this was concluded to be unrealistic by Dekker (2020). The initial thought of austerity is mentioned by Flyvbjerg et al. (2018) as a wrong approach to prevent project failure: the real problem that should be dealt with is not the cost overrun itself, but the root-causes of it. This is largely overlooked in the current execution of projects. Examples of projects, like the two mentioned, indicate a lack of capability to prevent project failure. Scope changes, complexity and political influence for example are causes of project failure, but if the actual root causes for these can be identified and reacted to, the problem can be solved better (Flyvbjerg et al., 2018).

Van Heel et al. (2019) mentions that the successfulness of construction projects depends on the interaction between people, process management, project management, and technology. They

conclude that more attention towards understanding the people aspect in projects is needed to reduce project failure, especially during early project phases (Van Heel et al., 2019).

Signs that can indicate future project failure, such as cost overruns and time delays, in early project phases are Early Warning (EW) signs. Early Warning (EW) signs are defined by Haji-Kazemi (2015) as follows: “An EW sign is a specific element, happening or event which shows that the risk event will actually realize. The EW sign does not provide information on the exact time of the materialization of risk; neither does it reveal its expected magnitude. Rather it acts as an alarm which triggers action in order to either prevent the realization of the potential problem or possibly lessen the undesired consequences.”

The failure of a project often arises from accumulated risks, or risk outbreaks (Vondruška, 2014). Focussing on Early Warning to identify and act on possible future problems as early as possible in projects can form part of the solution to prevent or reduce project failure (Haji-Kazemi, 2015). Being aware of indications of potential problems early on allows for more time to react to threats.

1.2 Research gap

To be able to anticipate the development of problems in projects, research has been done to describe the phenomenon of Early Warning, to describe how reactions to EW signs can be formed in a project, and to find barriers that can potentially prevent reactions to an EW sign from taking place (Haji-Kazemi, 2015). Mechanism(s) behind these barriers and other reasons why Early Warning signs are not responded to in practice are not yet researched in detail. A mechanism is defined as “the observable response made to a situation and the unconscious processes underlying it” (MeSH, 2021).

Haji-Kazemi (2015) concludes that further research is needed into how EW signs are influenced in a project: “Conducting a more detailed examination of real life projects (…) in order to scrutinize the real challenges, limitations and obstructions towards effectively carrying out the EW procedure”. Wijtenburg (2018) concludes that especially communicational and organisational effects are underrepresented in current research when applying it to construction projects. There is not enough understanding of what conditions and mechanisms in construction projects influence whether a response to an EW sign is made, especially regarding soft factors in the project environment. Depth is missing in the current description of barriers influencing the response to EW signs. The current focus is on a rational system perspective, while emphasis on the people who form the project organisation is missing (Walker, 2011). Walker (2011) states that the increasing complexity of the construction industry requires better understanding of the way people behave to improve the results of construction projects. The field of organisational behaviour in construction projects that can be used to create this insight is underexposed in research (Walker, 2011).

Research on the topic of Early Warning in projects focuses mostly on projects in general and not on construction project management specifically (Othman et al., 2018). Other literature on Early Warning and barriers uses mostly data from project management practices from multiple disciplines combined, such as IT, oil and gas. Research that does focus on construction management does so from a client’s perspective. Research from the perspective of a contractor can bring new perspectives. In the current landscape, clients tend to transfer more risks and responsibility of construction projects towards contractors (Zadeh, 2019). Early Warning can improve their control on project results.

As research thus far hardly focuses on construction projects alone, there is also little focus on response to EW signs for different phases in construction projects, such as the tender phase or design phase.

1.3 Research goal

The goal of this research is to explore what mechanisms influence the response to EW signs in construction projects from the perspective of a contractor, and to better understand how these mechanisms are shaped in projects and the construction organisation. This research is conducted at a contractor and from the perspective of a contractor.

Assessing construction projects with an organisational behaviour perspective can help form insights in the process of reacting to EW signs in projects (Walker, 2011). Organisational behaviour theory assesses behaviour in projects from different levels (Li et al., 2019). The project is not only seen as one temporary organisation, but also as a collaborative effort of individuals. By applying the perspective of organisational behaviour theory on Early Warning response in projects, potentially new insights in EW response can be found. The same construction organisation influences behaviour of different projects, teams, and individuals.

Findings are used to provide recommendations to improve the ability to recognise and respond to EW signs in construction projects. Better understanding of how the response to EW signs is influenced should lead to a more effective EW procedure in practice, with the aim of reducing project failure such as time delays and cost overruns.

1.4 Research question

The following research question is formulated to cover the research goal:

> *How is the response to Early Warning signs in construction projects influenced?*

To be able to answer this research question by applying grounded theory methodology, the following sub questions are formulated:

SQ1 *What concepts can be related to the response to Early Warning signs in construction projects?*

SQ2 *How is the response to Early Warning signs influenced by the organisational level?*

SQ3 *What mechanisms influence the response to Early Warning signs in construction projects?*

SQ4 *How can obstructions for addressing Early Warning signs in projects be mitigated?*

1.5 Thesis structure

This thesis is structured as follows. Chapter 2 describes the research design and explains the grounded theory approach used in the research. Chapter 3 provides a theoretical background on Early Warning signs and responding to Early Warning signs in projects, and presents a conceptual model of the relation between the response to Early Warning signs and organisational behaviour theory. Chapter 4 explores the organisational level of the construction organisation. Chapter 5 presents the case study at project level. In Chapter 6 these findings are used to form recommendations to mitigate obstructions for an Early Warning response in projects. Chapter 7 contains a discussion on the results and the research. In Chapter 8 the research questions are answered and the conclusion and recommendations are presented. Figure 1 visualises this structure.

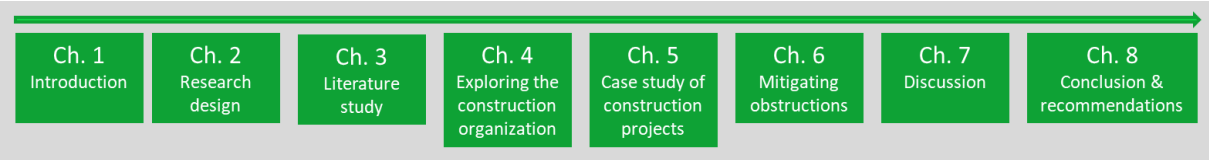

Figure 1. Thesis structure

2 Research design

This chapter presents the research design. First an overview of research characteristics and scope is given (Section 2.1). Section 2.2 explains what type of grounded theory is applied in the research and why that type is selected. Section 2.3 presents the research framework and explains how the sub questions formulated in Chapter 1 will be answered, providing details on research methods, and input and output of each sub question. Section 2.4 focuses on validity of the research.

2.1 Research characteristics and scope

The objective of this research is to identify conditions and mechanisms that influence whether or how is responded to Early Warning signs in construction projects. As the research gap presents, there is no clear understanding about what underlying factors and mechanisms influence the responsiveness to EW signs in construction projects. Because of this, the research is qualitative and has an explorative character.

A grounded theory (GT) approach will be used because of the explorative character of the research (Fellows & Liu, 2015). As the researcher explores the subject and forms conclusions on a real world phenomenon, the research can be characterised as constructivist (Bryant & Charmaz, 2007). Grounded theorists however differ in the role they assign to the researcher in a GT research. Because of the variety of different grounded theory approaches, next section will substantiate what type of grounded theory is applied, why, and how this is done. GT is an inductive approach (Fellows & Liu, 2015). This is fitting for a subject where little prior research is available.

The research is conducted from the perspective of a contractor and data is gathered at a contractor. The research is focused on EW signs in construction project management in the Netherlands. This research will focus on the early phases of construction projects. Early intervention gives most time to react, and early phases are mentioned as ideal for identifying EW signs (Othman et al., 2018).

2.2 Methodology: grounded theory

2.2.1 Grounded theory characteristics

Glaser and Strauss first described grounded theory in 1968 (Glaser et al., 1968). The grounded theory approach is aimed towards theory development (Fellows & Liu, 2015), rather than testing existing theory (it is inductive). Grounded theory can be used to gain theoretical insights, for a subject with little prior research (Verschuren et al., 2010). This is fitting for the area of Early Warning signs. By developing theory based on data from practice, it is ‘grounded’.

There is no consensus on how a research applying grounded theory should be conducted, as multiple versions or perspectives are developed over the years. Next section describes these differences. However, it is argued that all these versions are part of one method, as they all share a common foundation (Berterö, 2012) or a core set of shared procedures (Timonen et al., 2018).

Shared across all GT versions are: the use of data for developing theory, which makes the theories ‘grounded’ (Timonen et al., 2018). Also, all versions are developed to try to capture and explain context-related (social) processes. All GT versions make use of theoretical sampling (Timonen et al.,

2018). This is a process of collecting data based on concepts that emerged from earlier data. Data collection and data analysis take place simultaneously in GT, this is the constant comparative method.

In grounded theory in general, concepts and categories are gathered, compared and connected. This is called: coding. Three main steps are mentioned (e.g. by Fellows & Liu, 2015; and Verschuren et al., 2010): open coding, axial coding, and selective coding. The process of data gathering and coding is iterative and continues until data saturation.

1. Open coding: Collected qualitative data, interview transcripts, are broken into parts and labelled with 'codes'. An example of breaking a transcript into parts is line-by-line coding, where every line in an interview transcripts forms a part that can be coded. A theoretical background section can be part of the data also. Sensitising concepts can be explored initially in the theoretical framework, although not all versions of GT agree with this. Categories and concepts are gathered that could help interpret what the data tells about the phenomena for which a theory will be developed. In research, sensitising concepts can be used as guidance in the process of searching for meaningful data, while the sensitising concepts are not well defined yet (Bryant & Charmaz, 2007). After no new major categories or processes emerge from the data, open coding is finished.

2. Axial coding: Categories are re-sorted, links and relationships between codes emerge during this re-sorting. Codes will be grouped and linked in categories, that function as axis. Core phenomenon, causal conditions, and consequences are connected.

3. Selective coding: key concepts and their relation to the researched phenomenon are determined. Categories are connected together into a core category. This core category represents the new insights emerged from the research.

2.2.2 Differences between versions of grounded theory

By comparing differences between the approaches, a deliberate choice for a GT approach for this research can be made. There are three main perspectives for applying GT (e.g. Singh & Estefan, 2018), named after the theorists that created them: Glaser, Strauss and Corbin, and Charmaz.

<u>Differences in philosophical points of view</u>

Main differences exist in the philosophical considerations regarding perspective (which influences the position of the researcher in his/her research), and the extent to which they prescribe standardised methods in their perspective.

Glaser's perspective (also called: classical grounded theory), is a positivistic perspective, that believes one reality exists that can be captured in a theory (Glaser et al., 1968). The researcher functions as a distant observer.

Strauss and Corbin's perspective (Straussian grounded theory) is more post-positivist (Singh & Estefan, 2018): multiple viewpoints or realities can exist on a phenomenon of interest. The researcher is an observer and should be as objective as possible. According to Straussian grounded

theory concepts and categories already exist in reality and need to be discovered by coding (Glaser et al., 1968).

In the perspective of Charmaz (constructivist grounded theory), researchers actively engage in the data that they gather (Gibbs & Charmaz, 2015). This perspective is a constructivist-interpretivist perspective. There are not a select amount of realities that can be captured according to Charmaz. Rather, all formed theories are interpretations of reality and constructions. What actually is in the world does not matter.

Differences in the use of prior knowledge of the researcher

There is debate on whether and how prior knowledge can be used in a grounded theory research. Prior knowledge of the researcher on a topic leads to biased data interpretation according to Glaser (1978). However, Strauss & Corbin (1998) suggest to formulate research questions based on personal and professional experience of the researcher, or based on literature. Also Charmaz suggests this (Bryant & Charmaz, 2007). Charmaz also suggests exploring sensitising concepts, that can be found in literature, to be able to link to (parts of) these concepts in the coding process.

Differences in use of literature

The use and timing of the use of literature in research that applies grounded theory is much debated as well. Glaser (classical grounded theory) argues that knowledge on a subject influences the researcher, and less knowledge is better. Glaser only allows the use of literature after data analysis has concluded, and the researcher should “ignore literature prior” (Scott & Glaser, 1971).

Less conservative perspectives of Strauss & Corbin, and Charmaz, recognize that researchers can contaminate data with literature, but that they should be aware of that and should try to minimize the impact of prior knowledge on their research (Bryant & Charmaz, 2007). Strauss & Corbin suggest to use literature before and after data analysis takes place. Strauss & Corbin see a role for literature to direct theoretical sampling and to help with concept development, and defining properties and dimensions from the data.

Charmaz allows literature to be used during the whole research, and encourages to use new insights from literature actively (but warns that the outcome of the research should not be steered significantly by literature). Charmaz promotes the use of literature for example to gather background information and recent findings on phenomena that pop up during data gathering (Gibbs & Charmaz, 2015). Charmaz argues that a literature review on the topic in general is significantly different from using literature to influence data analysis.

Several reasons for including knowledge from prior research in a grounded theory study are mentioned in literature. Reading literature enables the researcher to become theoretically sensitive to the data (Hickey, 2016). Being able to apply earlier findings from data, could strengthen the validity of the research. Literature can be used in GT to develop themes emerging from the data (Hickey, 2016). Dunne (2010) sees an important role for using literature in a grounded theory research to ensure a study has not been done before, to contextualise the study and reveal how other studies researched a certain phenomenon before, to avoid conceptual and methodological pitfalls, to help the researcher develop sensitising concepts, and to prevent the researcher from getting criticism of being empty-minded instead of open-minded.

A literature review is helpful in understanding the current conversation on the topic of research (Hussein et al., 2017). The same researchers that advice postponing literature review until data gathering and analysis is completed, are the experienced researchers who already have an extensive knowledge of the topic they conduct research on (Bryant & Charmaz, 2007), while novice researchers do not have this knowledge yet.

An important reason against using literature in a grounded theory research is that reading literature can potentially steer the course of the research. Henwood & Pidgeon (2003) therefore opt for theoretical agnosticism, to not let a research be influenced by literature. They mention that literature could lead to the addition of irrelevant concepts and ideas to the research.

2.2.3 Grounded theory perspective used in this research

Despite the differences in main grounded theory perspectives, it is clear that it is important to avoid steering the data gathering process and to not influence the phenomenon. It is also important that literature does not steer the research, but is used mainly for orientation in existing knowledge.

The GT approach of Strauss & Corbin will be followed in this research. Their use of literature prior to data analysis is one of the reasons for this. Conducting grounded theory using the Strauss & Corbin perspective also benefits novice researchers (McCann & Clark, 2003) as they prescribe a structured approach to analyse data. Their approach also emphasises the importance of contextual as well as symbolic and interaction influences, on micro- and macro scale.

2.3 Research framework

The aim of each sub question (SQ) will be described and research method(s) used to collect data will be mentioned. An overview of the research approach is visualised in figure 2.

RQ: How is the response to Early Warning signs in construction projects influenced?

	Q1	Q2	Q3	Q4
	What concepts can be related to the response to Early Warning signs in construction projects?	How is the response to Early Warning signs influenced by the organisational level?	What mechanisms influence the response to Early Warning signs in construction projects?	How can obstructions for addressing Early Warning signs in projects be mitigated?
Input	Literature on EW signs and project failure	Internal company documents, guidelines, interviews	Framework of concepts related to the effectiveness of and response to Early Warning signs	Overview of mechanisms influencing the Early Warning response in practice
Research method	Literature review	Desk research, interviews	Case study	Literature review Expert meeting
Result	Framework of concepts related to responding to Early Warning signs in projects	Overview of how the response to Early Warning signs is organised and influenced by the construction organisation	Underlying mechanisms influencing the response to Early Warning signs	Areas of concern and recommendations to mitigate obstructions for responding to EW signs, evaluated with first feedback from experts

Figure 2. Research approach

2.3.1 SQ1: What concepts can be related to the response to Early Warning signs in construction projects?

Exploration of the field of study is the first stage in the grounded theory approach. From literature, possible mechanisms and factors influencing the EW response are explored. Sensitising concepts in this context are found and explored initially, based on literature. Literature on the Early Warning phenomenon, EW signs, and responding to EW signs are addressed. Findings are grouped in the levels of organisational behaviour described by Li et al. (2019): organisation, project, team, and individual level. This framework functions as a guidance at the start of the grounded theory research. Databases from which literature is retrieved are Google Scholar, Scopus, and TU Delft Library. A variety of keywords were used in this process, to also cover literature that uses synonyms for Early Warning signs for example. Search terms are: "Early Warning", "weak signals", "soft signals", "Warning signs". Variations of search terms with the following additional terms were used to find literature relevant for the topic of this research: "construction sector", "project performance", "project failure" and "construction projects".

2.3.2 SQ2: How is the response to Early Warning signs influenced by the organisational level?

This sub question aims at finding how the construction organisation itself, from the organisation level (macro level), tries to or can influence the response to Early Warning signs in projects. Desk research is conducted to assess documents, for example general guidelines or process descriptions. Three employees working at organisational level are interviewed to explore how Early Warning is organised at construction organisation level. Also sensitising concepts can be found and/or explored from this level. Purposeful participant sampling is applied for this selection. The aim is to gather insight from two points of view: the response to EW from the formal quality system side and the implementation side of these formal guidelines in practice. Someone in a manager's position, steering different projects while working on the quality system, can be placed in between these viewing points and can add a different third point of view. Depending on the position and experience of the interviewee with certain areas of the EW approach in the organisation, the interview will delve deeper into the formal procedure or the actual behaviour of the interviewee when encountering EW.

2.3.3 SQ3: What mechanisms influence the response to Early Warning signs in projects?

Factors, and sensitising concepts gathered from literature are used as starting points to answer this sub question. A case study on project level is conducted on three construction projects. The aim is to explore events in projects taking place leading up to project failure, whether or not EW signs were recognized or missed, and to describe the mechanisms influencing the EW response found in practice. There is a focus on the design phase, early on in the execution phase of the projects. The case study has a retrospective perspective on the events.

A case study can be used as a source of insights and ideas, and to describe phenomena (Fellows & Liu, 2015). The case study is conducted with a multiple-case design (Yin, 2018). The case study has a replication design, with multiple cases acting as multiple experiments in the research (Yin, 2018). Findings from the multiple cases are compared to find theoretical insights from the data: underlying mechanisms influencing the EW response.

Three projects are part of the case study to be able to gather data from projects with multiple characteristics. This number allows for in-depth exploration and analysis (Schoch, 2020). Also, selecting less projects increases the possibility of only selecting extreme cases.

Selecting case study projects

Potential case study projects are selected based on the following characteristics, purposeful sampling is used. The projects should be relatively large, and contain a technically complex part (as EW is theorised to be more important for more complex projects). Projects should be finished, or partly finished, as otherwise openness of interviewees and documentation cannot be fully assumed. Documentation of the projects should be available, such as progress reports, meeting reports, and the organogram. Project documentation offers accessibility to data, which is important for a case study (Yin, 2018). The documentation can contain EW signs with a description of when they were noticed and what was done with these signs. Prior to selection, explorative conversations took place to find fitting case projects that meet the sampling characteristics.

To select cases, first the project manager of a project is interviewed. After this explorative initial interview, three projects matching the selection characteristics are chosen. A specific event that occurred in each project is selected after the interviews with the project managers to analyse in detail. The event caused time delay or cost overruns for a particular part of the project. At these events, potentially Early Warning signs were missed, identified, or used. One project in reality can be split into several parts. At each part other parties can be involved, other factors and problems can play a role in each part of a project. By focussing on events instead of the project as a whole, a more in-depth analysis regarding factors influencing that particular event can be made instead of a general analysis of the whole project.

Data gathering

During the case study, data for the selected cases is gathered through project documents and by conducting in-depth, loosely structured interviews with personnel from the projects. Five interviewees per project are selected with a snowball technique (a type of convenience sample) and the theoretical sampling of grounded theory as basis. Convenience sampling is a non-random sampling technique (Emerson, 2015). Snowball sampling is used to access hard-to-reach populations, uses networking characteristics, and is flexible (Parker et al., 2019). This networking characteristic is ideal for project management, as the organogram of the project already contains the potential network of interviewees. The snowball sample depends on the resources and contacts available to the researcher, which is often a limitation (Parker et al., 2019). For construction projects however, the selection possibilities are already relatively small. Interviews with each new interviewee regarding a case using the snowball sampling enabled asking for more details of the event of interest, closer to the core of the event, to find out what happened in detail.

Data analysis

Interviews are transcribed and the transcriptions are analysed by coding the data according to the grounded theory methodology (Bryant & Charmaz, 2007). This is done by using the software program NVivo 12. Sentences describing how was acted, or reacted are labelled with this software. These labels (codes in grounded theory) are clustered into themes. A deductive theoretical framework formed with concepts related to the response to EW signs from literature is used as basis for the coding process. The framework is extended with inductive codes and themes that emerged from the interview transcripts and the extended framework functions as codebook. A factor can be seen as important when it is mentioned by multiple interviewees, however also codes mentioned by less interviewees can be important. Context and impact are important to take into account in the process of analysing data. For each case individually, a case analysis is made. Next, the findings from the three case study projects are compared to be able to describe mechanisms that influence the response to EW signs.

2.3.4 SQ4: How can obstructions for addressing Early Warning signs in projects be mitigated?

The goal of this sub question is to use the findings from the case study section to create an overview of areas of concern and formulate recommendations that can improve the response to EW signs in construction projects. These will be validated with help of experts from a broad field of expertise within the construction organisation. In a discussion they reflect on obstructions and recommendations based on aspects such as practicality. Findings are discussed in a presentation to the experts in a group session. The experts are selected based on their experience in projects as well as on managing the organisational level, and are expert in different fields relevant to project management, to allow discussion from multiple viewpoints in the expert meeting. As participants for the expert meeting, 4 experts are invited who are part of the construction organisation with different fields of expertise. Two experts from the organisation's management level, and two focused on projects. Some experts worked at different organisations over the years, other experts have a long working experience at one particular construction organisation.

2.4 Validity of the research

According to Yin (2018) the validity of qualitative (case study) research should be tested on four major aspects: construct validity, internal validity, external validity, and reliability. Construct validity is given attention by using multiple sources of evidence, such as multiple interviewees stating the same fact, or checking interview data with project reports. Internal validity of the research is given attention by reflecting on findings with existing literature. Also findings in the case study are supported with 'thick' descriptions (Houghton et al., 2013): accounts of the context, and raw data (citations). Selecting a small number of cases in a case study pressures the external validity of the research (Verschuren et al., 2010). By applying strategic sampling of case study projects, and using the snowball technique to select interviewees, the effect of external validity is tried to be minimalised. By developing a case study database (codebook), and by using a consistent case study protocol, the reliability of the case study is given attention (Yin, 2018).

3 Exploring literature: Early Warning and organisational behaviour

The sub question answered in this chapter is: “What concepts can be related to response to Early Warning signs in construction projects?”. Factors, mechanisms and concepts from literature related to the response to Early Warning in projects are gathered in this chapter. These concepts are assessed from the perspective of organisational behaviour theory as well. They serve as starting points for the case study research described in Chapter 5.

First the phenomenon of Early Warning in projects will be explored (Section 3.1). Next, characteristics of Early Warning signs according to literature will be described (Section 3.2). Early Warning signs mentioned in literature are gathered (Section 3.3), as well as categories of Early Warning signs (Section 3.4). The current theory on how Early Warning signs could be processed and responded to is explored (Section 3.5). Theories on reasons for the response to Early Warning signs not taking place are gathered from literature (Section 3.6). The theory of organisational behaviour in projects is explored and potential connections to Early Warning literature are mentioned (Section 3.7). Gathered categories of Early Warning signs and reasons for not responding to EW signs from literature are categorised over the OB theory levels (Section 3.8). The chapter will be concluded by answering the sub question (Section 3.9).

3.1 Early Warning phenomenon

Ansoff (1975) theorizes that crises or problems at firms seldom appear out of thin air. He mentions that systems and organisational dynamics of the planning process (strategic planning) make it impossible to handle dynamic and rapidly changing threats and opportunities. The approach of strategic planning then was dominant in firms and organisations (Holopainen & Toivonen, 2012). Ansoff argues for an approach that uses strategic flexibility, and strives for a balance between creative thinking and systematic management.

In order to act on future threats and opportunities, early symptoms of those threats and opportunities should be used. Ansoff mentions these symptoms as weak signals: “Weak signals are first symptoms of strategic discontinuities, i.e. symptoms of possible change in the future, acting as warning signs or signs of new possibilities” (Ansoff et al., 2019). Weak signals are described as initially inexact, vague, and difficult to interpret (Nikander, 2002). Even when a threat cannot be prevented, by acting early and being prepared, at least a complete response can be prepared beforehand (Holopainen & Toivonen, 2012).

Ansoff (1975) states that action could and should already be taken based on initial weak signals. There is however no consensus on this in literature. Ansoff did not provide results that could support his theory (Nikander, 2002). Some researchers believe the concept of acting on weak signals to be purely academic and not feasible in practice, while other research describing early indicators and soft forms of information seem to support the idea of reacting on weak signals (Haji-Kazemi, 2015).

Early Warning is used as a synonym of weak signals regarding the side of possible future negative impacts indicated by weak signals. Nikander (2002) used the weak signal theory of Ansoff (1975) as starting point and applied it to early warnings in the context of project management instead of only firms in general.

3.2 Characteristics of Early Warning Signs

In literature three dimensions of characteristics are distinguished: leading-lagging indicators, weak-strong signals, and soft-hard signs.

Williams et al. (2012) describes the dimension of leading vs. lagging indicators, where the distinction lays on the timing of prediction. When reacting to EW signs, there is an aim to act in a preventive manner. There is a focus on leading indicators, that should provide information before something happens. According to Haji-Kazemi (2015), lagging indicators (that provide information after something happened) can be useful as basis for learning, but not as a tool for EW.

As described by Ansoff (1975), there is a distinction between strong and weak signals, in the dimension of strength. The strength of a signal influences its accuracy, credibility, and rationality (Nikander, 2002). Stronger signals tend to be better detectable and are easier to interpret in a uniform manner. According to Holopainen & Toivonen (2012), a weak signal can evolve into a strong signal: first there is only a sense of a threat or opportunity, and as more information becomes available, such as characteristics, response possibilities and finally expected outcomes, the signal is strong. Signals can start weak as an idea, and when they become known to more people and in the end appear in reports, they grow stronger. When a signal is strong, it is possible to make and execute strategic plans, while for a weak signal it is important to stay flexible. A strong signal has a greater probability of realization (Ansoff, 1975). Different states of knowledge also require different techniques to handle the signals. Weak signals can for example be used by an expert in the vaguest state, but can only be used with quantitative modelling and forecasting once they are strong (Holopainen & Toivonen, 2012).

Haji-Kazemi (2015) also mentions a distinction between soft and hard signals. Williams et al. (2012) finds that interviewees when asked about EW signs often talk about soft as well as hard issues. He describes soft signals as less measurable than hard signals, more depending on ‘gut feeling’. Hard signals are more data related, for example finance or planning (Haji-Kazemi, 2015).

It is hypothesized that hard signals are most of the time lagging indicators, and soft signals more often leading indicators (Wijtenburg, 2018). Characteristics of EW signs are hypothesised to evolve over the time span of a project. Figure 3 (Wijtenburg, 2018) describes how EW signs in projects likely change in characteristics over time, from weak to strong, from soft to hard, and from leading to lagging indicators. The same sign can evolve as time moves on, and more knowledge becomes available.

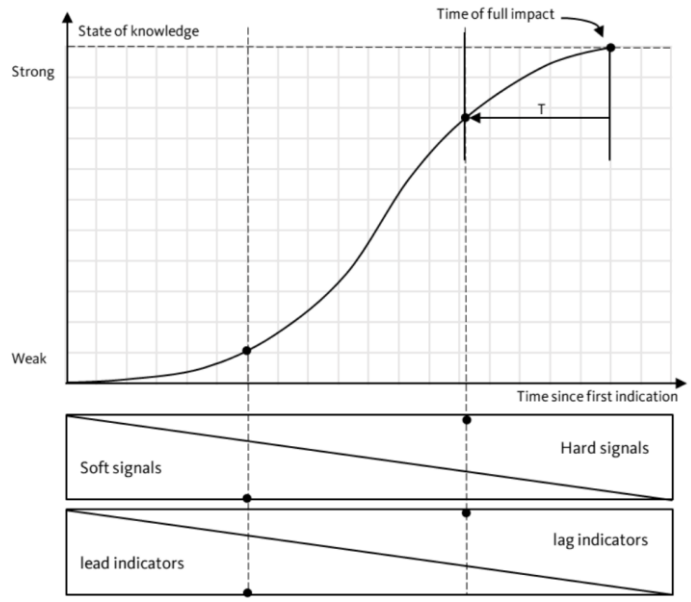

Figure 3. Hypothetical model of EW sign characteristics (Wijtenburg, 2018)

3.3 Identified Early Warning signs from literature

The complexity of the EW phenomenon and the variety of different characteristics of EW sign identified in literature already indicate that there is a wide variety of signals that can be categorised as EW signs. Studies gathering EW signs from practice show a large variety of different signs that can be identified. Two major studies composed extensive lists of EW signs from practice: Nikander & Eloranta (2001a) and Williams et al. (2012). Nikander & Eloranta (2001a) mention that in practice "countless" Early Warnings can be observed. This is why both studies categorise and sort identified EW signs instead of mentioning or describing the signs itself. Williams et al. (2012) however only presents a list of categories, and subcategories of EW signs and further does not mention what specific literal EW signs were observed in practice.

Nikander & Eloranta (2001a) show that EW signs stem from a variety of different sources: project planning, documents, project control, (project) parties, project work, expressions of personnel, project culture, and communication.

Figure 4 contains descriptions of 12 often encountered EW signs from the study of Nikander & Eloranta (2001a) to give an indication of EW signs that are expressed in practice.

Early Warning signs
Inconsistent behaviour of the contractor/supplier
A mood of non-satisfaction among personnel
Weak commitment to the project expressing itself
Bad quality of preliminary plans
A contract consciously drawn up to have little room for changes
Lack of speed and quality of work at the site
Being late is typical in the project
Same things come up again and again in meetings
Messages get lost along the way
Decisions are delayed
Quality of the reports is unsatisfactory
Old drawings are used at the construction site

Figure 4. Examples of EW signs encountered by Nikander & Eloranta (2001a)

3.4 Categories of Early Warning signs

The literature study of Othman et al. (2018) presents literature composing EW signs. Four relatively extensive studies were found through his literature study. An overview of them is created in table 1. These four studies used data from various project disciplines and different countries. Two of the studies (Hanna & Gunduz, 2005; Maity, 2017) gathered a list of EW signs through surveys (quantitative), structured them and used statistical analysis to find the most common categories of EW signs for project failure. The other two (Nikander & Eloranta, 2001; Williams et al., 2012) search for EW sign categories in a qualitative approach and structured them in groups.

Table 1. Overview of used literature for an overview of EW signs

Reference	Research method	Research size	Amount of EWS	Project types	Nationality
Maity (2017)	Factor analysis	200 questionnaires	8 EW categories, 34 EW signs	Construction industry	India (Kolkota)
Hanna & Gunduz (2005)	Logistic regression	116 questionnaires	7 EW categories	Mechanical and electrical contractors	USA (nationwide)
Nikander & Eloranta (2001)	Thematic interviewing, case study	17 project professionals, 4 case projects	9 EW categories, 68 EW signs	Industrial construction projects	Finland
Williams et al. (2012)	Case study, interviews	8 projects	10 EW categories, 56 EW signs	Oil and gas, construction, IT	Norway, UK, and Australia

These studies explored projects from different industries and disciplines and created an insight in EW categories encountered most (as can be seen in table 2). The EW categories presented by literature comprise EW signs that are different types of variables (e.g. independent, mediating). There is hardly further distinction of EW signs or categories mentioned in these studies. Williams et al. (2012) is the only study of the four that distinguishes characteristics in the EW categories presented in their study. They conclude there are two distinct ways in which EW signs are expected to be detected. Detection is expected to take place based on “gut feeling” or “through assessments”. By focussing on detecting EW signs through one of these approaches, the other EW signs stay undetected according to them.

Table 2. Overview of EW categories from the selection of literature

Qualitative	
Nikander & Eloranta (2001) (9 categories)	**Williams et al. (2012) (10 categories)**
Project group personnel (mainly behaviour)	*Process-related:*
Other parties in the project	Quality of information and documentation produced
Lack of proper documentation	Main risks are identified
Working within the project	Location decisions and complications from such
Project planning	Relevance of the proposed solution vs. needs
Communication	Guidelines for early phase assessments and "behaviour" were not followed
Project culture (differences and deficiencies)	The need for development of new technology
Project control and reporting	*People-related:*
Project manager and management	Sponsor with unclear expectations and role
	Leadership issues
	Project culture
	Missing competence in the project team
Quantitative	
Maity (2017) (8 categories)	**Hanna & Gunduz (2005) (7 categories)**
Project management deficiencies	Owner-contractor prior collaboration
Risk challenges	Design completion during tender
Project team commitment	Design completion start construction
Ethical and cultural issues	New equipment cost
Government interference	Experience project manager with project size
Control imposed by stakeholders	Experience project manager with project type
Financial and schedule challenges	Coordination of design issues Architect-Engineer
User requirement	

By comparing the EW categories from the four studies from table 2, four shared central themes seem recognisable from the data: internal collaboration, maintaining documentation, preparedness before starting a project, and collaboration between different actors. Table 3 exemplifies this overlap in central themes. The shared themes are now explained:

1. Internal collaboration in the project group covers most of the categories. It includes categories regarding the initial composition of the group (e.g. project group personnel), and categories regarding the functioning or effectiveness of the group collaborating (e.g. working within the project, project team commitment). Project culture can be seen as part of this theme.
2. Maintaining documentation is mentioned in the categories of documentation, project planning, quality of information and the reporting aspect of the category 'project control and reporting'.
3. The theme preparedness before starting a project consists of categories that relate to forming an idea of what to expect and what to encounter during the project. Expected difficulties (either based on new data or experience) and clear plans and visions apply to this theme. The complexity of the project is mentioned very little, only directly by the category 'need for development of new technology'. Complexity in practice is hardly seen by these four studies related to EW categories, or it is divided over other aspects such as preparedness.

4. Collaboration with actors outside of the own project group shows the attention to multiple categories that not inside the project group, but also interaction with actors outside of the project group impacts the performance of the project.

Table 3. Central themes in literature describing categories of EW signs

	Nikander & Eloranta (2001)	*Williams et al. (2012)*	*Maity (2017)*	*Hanna & Gunduz (2005)*
Internal collaboration	Working within the project	Project culture	Project team commitment	Coordination of design issues
Maintaining documentation	Project control and reporting	Quality of information produced	User requirements	-
Preparedness before starting a project	Lack of documentation	Main risks are identified	Knowing risk, financial and scheduling challenges	Design completion at start construction or during tender
Collaboration of multiple actor groups	Other parties in the project	-	Control imposed by stakeholders	Owner-contract prior collaboration

3.5 Early Warning Procedure model and identified barriers

Procedures describing the response to EW signs are aimed at better understanding the EW response. These procedures can be used to look for stages that seem most critical for a successful EW response.

The most developed and elaborated Early Warning procedure in literature is described by Haji-Kazemi (2015). She developed this model based on causes she concluded obstruct a response to EW signs in projects. The projects she based this procedure on, took place in a variety of disciplines. This makes the procedure applicable to a wider variety of projects than would be the case if it would have been developed for one discipline, however for a thorough application of a procedure, a more fit for purpose procedure will be more effective.

Haji-Kazemi's EW procedure model used the Decision Support Model of Nikander (2002) as basis. Nikander's model aimed to enable decision making based on the development of problems in projects, by supporting project management in project risk management. Nikander (2002) mentions his model as a 'mental approach, rather than a strict model of action', in other words: to improve insight in the phenomenon of project problems, rather than a guide of how to act.

Nikander's model implements the notion of information filters, theorized by Ansoff in 1975 (Nikander, 2002), although these filters are not literally visible in Nikanders model. Ansoff states that information should pass three filters before an action can be taken based on that information: a surveillance filter, a mentality filter and a political/power filter (figure 5). The first filter, the surveillance filter, is passed once an emerging signal is discovered by one or more actors. At the mentality filter the person receiving the information decides on whether the signal is important or relevant enough to send through. Historical relevance of the signal and individual judgement is important here. The political/power filter, focuses on how the decision-maker decides to act and on what information his/her decisions are based. Signals can be intentionally or unintentionally ignored (Holopainen & Toivonen, 2012).

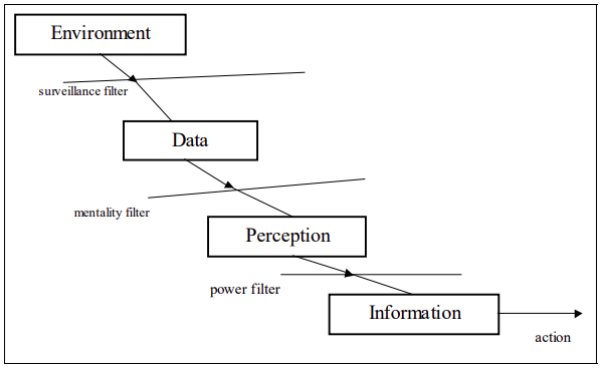

Figure 5. Ansoff's filters (Nikander, 2002)

Haji-Kazemi (2015) kept Ansoff's filters central in her EW procedure model (figure 6). By validating these filters in practice, she concluded that another filter was needed. The mentality filter is now split up into two filters: an observer mentality filter and a decision-maker mentality filter. This choice was made as the non-decision-maker and decision-maker both have significant other interests according to Haji-Kazemi (2015).

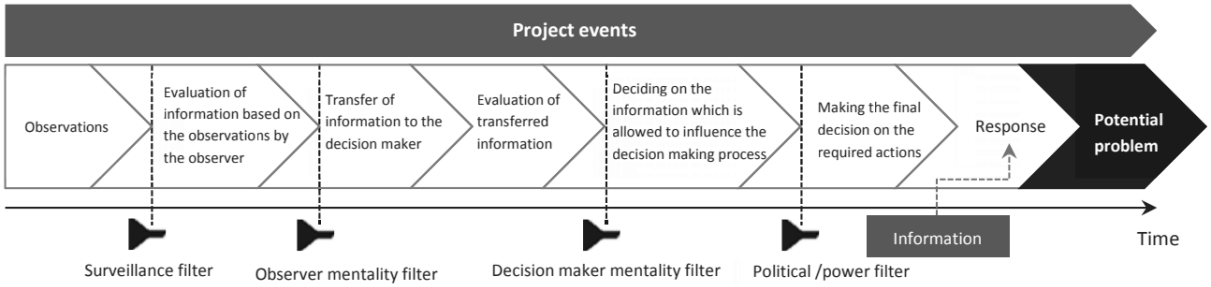

Figure 6. EW procedure (Haji-Kazemi, 2015)

Central in the EW procedure models are the stages that a piece of information has to pass to end up in a place where a response can be made based on the information. As no specific project discipline is used to build a model around, underlying mechanisms that might be specific to a project discipline such as construction project management are not caught in it. In general, the EW procedures focus on the actions of people in projects needed to use an EW sign rather than describing a structured, standardised, system based approach on how to best handle EW signs. For example, the first part of the model is 'observations', and does not describe where the observations should be based on (such as identification approaches or something else). The filters of Ansoff as key part of the models give an insight in what processes in handling EW are assumed to be critical. Wijtenburg (2018) concludes however that communicational and organisational effects are underrepresented in this model.

Barriers, factors for not responding to EW signs, are identified from literature and linked to the EW procedure model of Haji-Kazemi by Wijtenburg (2018). The highest ranked barriers mentioned are: optimism bias, time pressure, project complexity, uncertainty avoidance, fragmentation, client-contractor relation, management style and political effects. These barriers are matched with filters they influence in the model. One barrier can influence multiple filters.

Distinctions in EW sign types (e.g. detectable by assessment or by gut feelings, as described by Williams et al. (2012)) or distinctions between organisational levels (organisational field, project, team, or individual level, as described by Li et al. (2019)) are not mentioned in the EW procedure of Haji-Kazemi (2015). Everything is seen from the perspective of the project as one unit.

3.6 Reasons for not responding to Early Warning signs

Ansoff et al. (2019) theorizes on factors that complicate an EW response. These factors are not mentioned in a project specific context, but from a general business perspective. Weak signals are influential in this process, and are mentioned as synonym for EW sign (Nikander & Eloranta, 2001). A difference between mind-sets impacts the acceptance of a person towards managing weak signals (Ansoff et al., 2019). This means that individual characteristics such as experience influence whether weak signals are reacted to. The composition of project teams seems important for (not) responding to EW signs. A 'weak signal' mentality is mentioned by Haji-Kazemi et al. (2015) as part of the (decision-maker) mentality filter in projects. Haji-Kazemi et al. (2015) also mention 'unclear roles and responsibilities' in a project as cause for not responding to EW signs. This is also an aspect where hierarchy is involved.

Not being able to detect weak signals is another reason for not responding (Ansoff et al., 2019), as expertise and sensitivity are needed in the right combination among observers. He notes it is important to know what actions should be taken at what states of knowledge: when more concrete knowledge becomes available, then more concrete action can and should be taken (as described in figure 7). This means a certain preparation is needed from the organisation on how to act when what state of knowledge is reached.

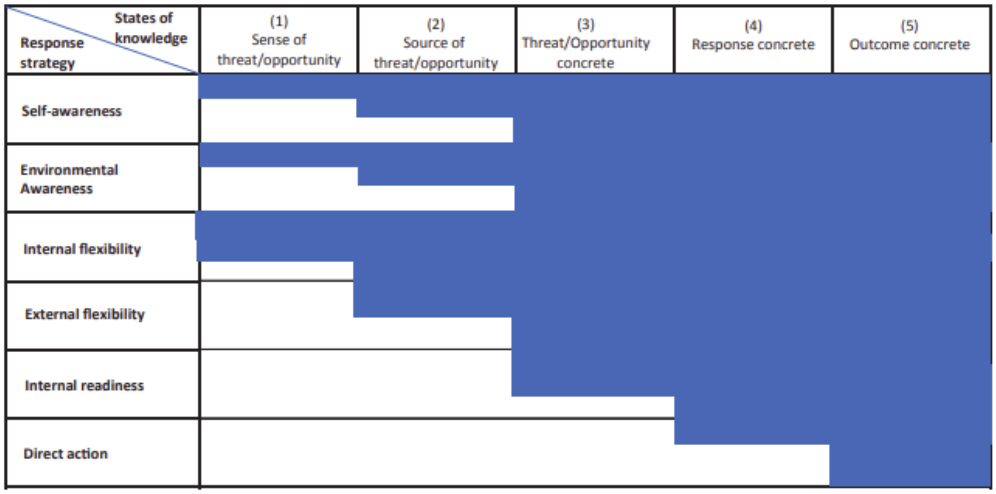

Figure 7. Ranges of response strategies (Ansoff et al., 2019)

Next to acting against a threat, early detection can also open up the opportunity of soften a crash response (Holopainen & Toivonen, 2012). Instead of only knowing the failure outcome when it actually arrives, by acting earlier the impact or severity can be reduced. Ad hoc crash responses are needed to achieve this.

Why there is no response to specific EW signs is researched further in the research of Williams et al. (2012) and Nikander & Eloranta (2001). They both qualitatively gather EW signs from practice (as shown in Section 3.1).

Nikander & Eloranta (2001) find that causes of problems and the problems they found influencing each other so much that the cause can be turned into a consequence of the problem. For example: bad management and leadership style causes scheduling problems, but because of scheduling problems the bad management and leadership style is strengthened. They conclude that a

phenomenon of chains is formed where an observation can be a warning, the problem itself or a cause of the problem, all depending on the time of observation. This makes interpretation of an EW sign and a correct response in practice even harder. Because of the complexity and short time frame available in projects to respond to an EW sign, Nikander & Eloranta (2001) conclude that the experience of managers in projects is very valuable to observe EW signs. For positions lower in the hierarchy, it stays unclear whether they should move observations upwards on the hierarchy ladder towards the manager, or if they should not bother paying attention to EW signs at all and leave that to the manager.

According to Williams et al. (2012) EW signs are generally not picked up because of a lack of understanding of project risk and uncertainty, a lack of understanding complexity, and problems regarding detecting people's tacit knowledge and responding and interacting with people in projects. They distinguish EW signs that should be detectable through assessments or based on 'gut feeling'.

Williams et al. (2012) finds in project case studies that actively using EW sign exercises to find EW signs can be useful but can also give an incorrect perception of trust by doing the exercise. Also the importance of frequently checking prior EW findings and revising them is mentioned. Communication is concluded to be even more important than the use of identification methods for EW signs. They mention aspects such as trust and good communication, that all seem to be connected to project team- and organisational culture. Importance is also given to attention for EW through the whole project.

Williams et al. (2012) mentions multiple reasons why there is no response to EW signs. They mention that projects are often caught by surprise by crises because no contingency plans were prepared. When trying to identify EW signs later in the project, EW signs are missed more frequently because of the intensity and busyness during the execution phase of the project.

Secondly they mention the lack of learning from earlier projects. This can be the case because no time is given to reflect on earlier projects (time pressure) or because project members are reluctant to 'air dirty laundry' (they lack motivation to do this). Another possibility is that the project team views their activities as too unique to use their experiences in future projects. Reflection reports that are made often lack a lot of details, such that incorporating experiences from that project in a future strategy is not possible.

Thirdly, self-assessments used in projects is often not effective enough according to Williams et al. (2012). Fourthly, different parts of a project that work towards their own goal underestimate the impact they have on other parts of the project organisation ('silo thinking'). Fifthly, the response to a discovered EW sign is more often to mention that everything will be fine than to actually react and change direction based on the EW sign (this behaviour effectively counters warnings).

Sixthly, there is an overall mismatch in incentives between the individual and the organisation: the individual has as main interest to gain experience from projects for themselves, and does not see the benefit of the organisation to secure experience in a central database. Williams et al. (2012) finds that EW signs are often purposely overlooked or not taken into account in the front-end phase of projects. This statement seems to support the idea that understanding the role of levels of organisational behaviour in projects is beneficial for a better EW response.

Finally, projects can be strongly influenced by politics. In that case, political pressure and powerful interests influence whether a solution is seen as urgent, instead of EW signs sent by project personnel.

Haji-Kazemi et al. (2015) also mentions reasons of why there is no response to EW signs in projects. The main conclusion of her literature review on this topic is that there is overall indecisiveness in the utilization of the risk management process for EW identification. She also mentions that cognitive biases can cause inefficiencies in the EW procedure within construction organisations.

Wijtenburg (2018) finds the most common and impactful barriers for reacting to EW signs in construction projects. These are: optimism bias, negative client-contractor relations, uncertainty avoidance, time pressure, fragmentation, management style, project complexity, and effects of politics on projects. Most of these were also identified by earlier mentioned literature on project management in general. New insights of importance here however are the impact of the client-contractor relation, fragmentation, and management style.

In summary, literature describes the following concepts related to (not) responding to Early Warning signs: weak signal mind-set, team collaboration, experience, optimism bias, preparation (e.g. ad hoc crash response), lack of learning from previous projects, negative client-contractor relations, uncertainty avoidance, time pressure, fragmentation, management style (and structure of hierarchy), project complexity, and effects of politics on projects, complexity of interpretation of signals and problem chains, prior experiences of project personnel, and expertise and sensitivity.

This is a broad variety of concepts. To be able to analyse from where in the construction environment they stem or can be found further structuring is needed. The OB theory levels can guide in this structuring.

3.7 Organisational behaviour theory in construction projects

Walker (2011) states that the study of individuals in construction projects and organisations is not formalised, while he expresses the need for collaboration in projects to end projects with a successful result. Organisational behaviour theory is mentioned as link to improve understanding of how this collaboration can be realised and understood. Walker (2011) uses the definition of organisational behaviour (OB) as: “the study of human behaviour in organisational settings, of the interface between human behaviour and the organisation, and of the organisation itself”. In this definition, three levels are distinguished: the organisation, the group, and the individual level.

Further researching the application of OB to the construction sector and megaprojects in particular, Li et al. (2019) conclude that four levels of OB classification fit the construction sector better. Their main argument is that the influence of both organisation and project should be reflected in different levels, as both can have a specific influence on behaviour that is underexposed when they are seen as one level. The schematic framework of this classification can be seen in figure 8. Research topics distinguished at the four levels from literature can be seen in table 4 as further clarification of differences between the levels.

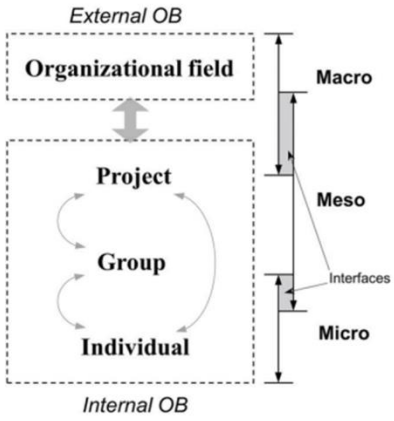

Figure 8. Schematic multilevel research framework of OB in megaprojects (Li et al., 2019)

The split in four levels is described in literature as follows:

Individual level

Within a project, there are many individuals, that behave, interact and influence the project performance as a whole (Li et al., 2019). Individual emotions, capabilities and motivation are important on this level. Most important individuals in project organisations are project managers, including aspects of strategic management, leadership and decision-making skills that impact the success or failure of a project. Decision-making also takes place on individual level, as an individual can decide to report something that for example can be defined as an Early Warning.

Group level

The group level is sometimes mentioned as team level in literature. Groups are mentioned as sub organisations in projects that grow and dissolve during the project, due to the dynamicity of the project. Not all groups in the project have the same interests. Communication, conflict, intergroup behaviour, power, internal stakeholders, and cross-cultural issues are important according to Li et al. (2019). Effective and efficient groups are needed to complete a project successfully. group effectiveness is important on this level for the project's success. Group culture, trust, multiculturalism, and conflicts due to inconsistencies in interests of project stakeholders are important. Shared values, attitude, and management approaches for these should be used to guide these aspects.

Project level

The project level is the level of the project organisation as a whole. It is temporary, and adapts to dynamic and the uncertain project environment. Within the project organisation, there are hierarchical structures as well as more informal matrix and network structures formed by informal organisational relationships in the project (Li et al., 2019). Governance structures need to evolve to adapt and be resilience to the environment that changes. To achieve the goals of the projects, behaviour of individuals and behaviour on group level is influenced.

Organisational field

This level can be seen as the field overarching all projects conducted by the organisation. Not only intra-, but also inter organisational relationships are identified on this level. The organisation can influence all other levels with policies and guidelines. From organisation level, the organisational structure and culture are affected (Robbins & Judge, 2018). Influences by politics or stakeholders are part of this level.

Table 4. Classification of research topics over OB levels (Li et al., 2019)

Level	Research topic	Cross-level research topic
Organizational field	Institutions, politics, culture, social conflict, stakeholder, external cooperation, social responsibility, citizenship behavior	Stakeholder, leadership, culture, cooperation, ethics, decision making, social responsibility, citizenship behavior
Project	Organizational structure, organization network, governance mechanism, governance system, governability, project culture	
Group	Communication, collaboration, teamwork, innovation, team decision making, relationship behavior, cross-culture, conflict, team culture, organizational learning	
Individual	Manager leadership, roles, trust, ethics, psychology	

3.8 Combining OB theory and EW literature

By using the definitions of the four OB theory levels as mentioned in section 3.7, the concepts found in literature in section 3.4 and 3.6 can be structured. This division over the organisational levels can improve the understanding of collaboration in a project setting (Walker, 2011). The concepts from literature are used as framework for the coding in the case study section of this research.

Table 5 contains the concepts found in literature in section 3.4 and 3.6, with the final column containing the framework. To decide what categories and concepts fit into what level of OB theory, definitions and descriptions from the study of Li et al. (2019) were followed. The main point here is that actions that can be accounted to an individual (such as the behaviour of the project manager) are mentioned as part of the individual level. Concepts such as communication, where at least two people are needed for it to make sense, are fitted in higher levels.

The project level stands out from this classification, as most Early Warning categories and concepts found in literature seem to relate to this level. This can be because the focus of the literature is on gathering concepts from projects as a whole. Another possibility is that some levels could be under-exposed and deeper understanding or root causes from higher level phenomenon in lower levels is missing.

Table 5. Theoretical framework: categories and concepts from literature structured in levels of OB theory

EW categories mentioned in literature	Concepts from literature regarding not responding to Early Warning signs	Theoretical framework
	Organizational field	
-	Lack of learning from previous projects	Learning from previous projects
Control imposed by stakeholders	-	Control imposed by stakeholders
Client with unclear expectations and role	-	Client with unclear expectations and role
-	Effects of politics on the project	Effects of politics on the project
	Project level	
Project management issues	-	Project management issues
Coordination of design issues	-	Coordination of design issues
Guidelines for early phase assessments and "behaviour" were not followed	Uncertainty avoidance (e.g. leads to too much focus on rules and procedures)	Uncertainty avoidance
Project control and reporting	-	Unclear documentation
Lack of proper documentation	-	Project structure
Complexity	Project complexity	Complexity (of techniques)
Collaboration between groups	Negative client-contractor relationship	Collaboration between groups
Planning issues	-	Planning issues
Schedule challenges	Time pressure	Time pressure
Financial challenges	-	Financial pressure
Main risks were(not) identified	Lack of preparation (no ad-hoc crash responses)	Preparedness before starting project
Design completion during tender		
Design completion start construction		
Client-contractor prior collaboration	-	Client contractor collaboration
	Group / team level	
Collaboration in the group	Team collaboration	Group collaboration
Communication	-	Communication
Group culture	Optimism bias	Group culture (commitement as team, optimism bias)
Team commitment	-	-
Missing competence in the project team	-	Missing compentence as project team
-	Fragmentation of information (lack of knowledge transferring)	Fragmentation of information
	Individual level	
Individual behaviour	Weak signal mind-set and sensitivity	Individual behaviour & mind-set
Quality of the manager & leadership	Project manager's management style	Manager characteristics
Experience project manager with project size	Experience of personnel	Experience
Experience project manager with project type	-	-
-	Expertise of personnel	Expertise

3.9 Conclusion of the literature exploration

Literature is explored to answer to the first sub question:

Q1 *What concepts can be related to response to Early Warning signs in construction projects?*

Literature suggests that the response to EW signs takes place in repeating patterns on project level and indicates that EW signs evolve over the lifespan of a project.

Filters are seen as the main bottlenecks for responding to EW signs. Barriers at each filter are mentioned as factors influencing these filters. In this view, there is no distinction between different levels in a project, while organisational behaviour theory suggests that there are multiple levels in projects that are important to distinct towards to understand behaviour better. Focusing on individuals in a project, groups of individuals, the project as a whole, and the organisation overarching these levels could improve understanding of how Early Warning signs are responded to or could be responded to.

Gathering Early Warning categories from literature and sorting them over the levels of organisational behaviour shows that a lot of concepts are related to project level (as can be seen table 5). This can indicate that the other levels are underexposed in research. The role of other concepts from lower levels on the concepts from project and organisation level mentioned in literature will be of attention in the case study part of this research.

Reasons for not responding to EW signs mentioned by literature include more concepts related to the individual level within projects, but do not describe the link between these individual concepts and concepts on other levels. Linking concepts from multiple OB theory levels together can give insight in underlying mechanisms of importance for the response to EW signs in projects.

Concepts from all OB levels seem to be connected to the response to EW signs, although not all levels are mentioned as frequent in current literature.

4 Exploring the influence of the construction organisation on the Early Warning response

This chapter investigates how the construction organisation deals with Early Warnings. The macro level organisational field behaviour as described in OB theory (Li et al., 2019) can be explored, as well as its influence on the lower levels of OB.

The sub question answered in this chapter is: “How is the response to Early Warning signs influenced by the organisational level?”. Factors that can be linked to the EW response by the construction organisation are gathered.

This chapter is structured as follows. Section 4.1 explains the approach of desk research and interviews to gather insight into how the construction organisation deals with Early Warning. Section 4.2 describes the findings. Section 4.3 concludes the chapter by presenting an overview of gathered concepts on different OB levels from the construction organisation.

4.1 Approach

4.1.1 Goal

The goal of this chapter is to explore how the construction organisation influences the response to Early Warning signs. For this, concepts and sensitising concepts that can be linked to (not responding to) EW signs are gathered. Both the formal guidelines of the construction organisation and practical application of these guidelines are looked at.

4.1.2 Research methods

As guidelines are written down, desk research for these guidelines is done. To assess the completeness of these guidelines, the implementation, and approach used for EW signs in projects, semi-structured interviews are conducted. The interviews are not aimed at one specific project, but at the way the construction organisation tries to steer all projects. Interviews and desk research are done simultaneously.

4.1.3 Interviewee selection

To be able to gather a complete overview of the EW approach from the construction organisation, personnel from different departments with different functions are asked to participate in the interviews. Interviewees are selected based on their position in the construction organisation and experience at the construction organisation.

Three interviews were conducted with personnel working at different positions: A quality control specialist, focusing on general project guidelines. A system engineer, who has to implement these formal guidelines in practice. Also a cluster manager, coordinating different projects that apply these guidelines was interviewed.

The following three interviewees were selected:

- Interview 1: QAQC (Quality Assurance / Quality Control) specialist, circa 10 years of experience
- Interview 2: System Engineer, circa 10 years of experience
- Interview 3: Cluster Manager, more than 10 years of experience

The first interview with a Quality Assurance specialist should give insight into how the formal procedures and guidelines are set up, how they ideally should be implemented and how the system is regulated. The second interview with a Systems Engineer should give insight in the way Early Warning is handled in projects, influenced by guidelines from the construction organisation itself. The third interview with a Cluster Manager can give insight into how the construction organisation sees EW, and how or whether they commit to influencing behaviour towards EW signs.

4.1.4 Interview design

The interview procedure can be found in Appendix A. The interview is designed to be semi-structured (Yin, 2018), to cover topics that will be mentioned next, while also creating space for open answers and deeper questions during the interview.

The interviews are split in several parts. In the first part (part A), the research and the goal of the interview is described in outline. Not too much detail is mentioned to not influence the answers of the interviewee. The processing and handling of the data is explained and permission is asked to record and transcribe the content of the interview.

Next in part B, some details on the function and years of experience of the interviewee within the construction organisation are asked.

Part C starts with asking whether Early Warning signs are recognised, to build a picture of whether there already is some experience with Early Warning. After comparing the definition of Early Warning by the interviewee with the definition according to literature, a link is made with the experience of the interviewee with Early Warning or related aspects in the working field. The formal approach of the organisation when encountering Early Warning signs is asked.

Part D reflects on encountering EW in practice and what is done with these experiences. Reflection or learning ability can be mentioned for example. Part E indirectly asks the interviewee about aspects that Haji-Kazemi (2015) describes as crucial steps in a procedure to respond to EW signs. This creates better insight into how steps that, according to theory, are crucial for an EW response are guided or take place in practice.

The interview concludes with part F, where there is the opportunity to ask questions by the interviewee and where possible missed points or clarifications regarding handling EW in the organisation are discussed.

After the interview, transcripts are send to the interviewee to ask for approval of the content.

4.2 Results

4.2.1 Procedures and guidelines

Management system description

The construction organisation structures its activities in a business management system. All three interviewees mentioned this system. The guidelines of the construction organisation regarding how projects are organised are described in this quality system. It serves as a reference containing steps and procedures that are described for projects with the aim of meeting all quality aspects. It contains the standard procedures and steps that should be followed in all projects. Processes focused on the construction project management or the deliverable are structured in a chronological order. Contextual road maps and supporting processes are needed multiple times during a project and are not chronologically ordered in the system. The chronological processes consist of subjects, inputs, actions and outputs. The system is visualised as a large flow chart. Non-chronological processes are linked when they are needed.

The business management system consists of three parts: a tender management system, a project management system and an asset management system. As the construction organisation focuses on infrastructure projects, the project management systems full name is project management system infra (PMI). The systems contain some overlap. This allows managing a case for only one of the three purposes by actually using only the management system targeted at this purpose. At the transition to a next system, extra checks such as a risk analysis are recommended to improve the flow of the project.

Limitations of the management system

The tender phase should flow into the project phase smoothly. In practice, this changeover brings risks and uncertainties as it is not likely that all information is handed over. Not all data from the tender can be accessed and used again in the project phase due to the way the system is designed: in separate sections. The system engineer mentions that in practice at the transition from tender to the project design phase, a new database is created. This reduces the information that is available on the project. Arguments for estimations for example can be lost. He mentions that it is “likely possible that EW related information is also lost this way”.

The aim of the construction organisation is to appoint tender phase personnel again in the project phase for an assignment. This would then reduce the impact of going from tender to project phase. However in practice this does not seem to happen often. One reason mentioned by the system engineer is that personnel is assigned to a project based on availability rather than composing the best possible team with most knowledge.

The PMI is “explicitly not used as a manual, but as a reference work, and to inform clients on the method of working”. Internal auditing of projects is another aspect for which the PMI is used. Not every step is literally dictated, as a lot of steps and procedures are open for interpretation of the representative of that step at the project. Experience of the personnel is important for this interpretation.

The aim of the organisation is to review and if necessary update the management system every year. For this, reviews of processes are distributed over several 'process owners'. Outside of these yearly reviews, requests for changes can also be made by everyone on a voluntary basis. In practice around 60% of the PMI is reviewed yearly. This indicates that some parts of the PMI can be outdated, and stay outdated for quite some time.

Responding to EW signs and the management system

The PMI is not prepared to facilitate Early Warning in particular. It focuses on hard factors and appoints responsibilities for creating reports, but does not mention active approaches for gathering of EW. An example is the verification of the project plan early on in the design phase. For this activity, no content is described that asks for input of personnel working on the plan other than the design manager who is responsible for this step.

A formal way to report EW related concerns is by escalation. There is little attention to escalation in the management system. Escalation refers to handing over or signalling points of concern or discussion to another position in the project organisation structure. The PMI only mentions the terminology 'escalation' in the preparation of the project agreement between client and contractor. The aim here is to establish 'escalation lines' in projects from the contractor to counterparts of the client with roughly the same authority in the project. Escalation lines within the project team are not mentioned as such. In practice, interviewees mention that "the organogram is used for escalation lines in the project team". This seems to indicate that there is not much attention to lower OB levels (individual and team level) in the PMI.

Outside the digital system, a guide was found describing how to deal with EW related information as individual, from the perspective of team- and project level ("flyer escalation procedure"). The folder did not mention explicit steps on how to escalate, but does mention with whom in a project certain concerns should be shared. Only one out of three interviewees mentioned the flyer. This indicates that it is not widely known by personnel that this flyer exists. Because it was not brought up more than once, it could be possible that the contents of the guide are not used in practice.

4.2.2 Factors mentioned on organisation level that could influence the EW response

Next to general guidelines, other practices and common behaviour organised from construction organisation level can influence the EW response.

Experience of personnel is by all three interviewees mentioned as important for working on projects. This experience is placed at the individual behaviour level of OB theory. Experience is needed to recognize Early Warnings, to decide how to communicate the Early Warning, and to choose how to react to the Early Warning. From a system perspective, experience is critical to decide how to act, as no formal guidelines for behaviour or identifying Early Warning signs exist in the management system. From a practical perspective, experience of individuals is critical to recognize deviant behaviour or events.

Learning as organisation from past projects and applying this knowledge in new projects is not recognized in practice by the interviewees. Presentations to reflect on ending projects are organised regularly. This which indicates that reflection takes place within project teams and individuals benefit from gaining knowledge and experience from these presentations. Within departments however,

reflection seems to barely take place. There is no standard within the organisation to write down lessons learned during or after a project. The PMI also does not contain specific instructions on how to evaluate projects. Not all (small) problems are stored in databases or documentation, which makes it hard to reflect on these events. All interviewees mention that knowledge and experience of past projects benefits individuals, but the organisation does not partake in developing this knowledge. Learning as an organisation seems to not take place. This likely makes it harder for inexperienced personnel to identify EW signs in projects, given that experience is mentioned in literature as important for the response to EW signs (Williams et al., 2012).

The high complexity of projects and time pressure are mentioned by one interviewee as the reason that formal guidelines are not often looked at. In projects, people tend to use their own expertise and experience to estimate how they should handle situations rather than using new insights or ask for external feedback.

The term 'Early Warning' is not recognised by interviewees from their project experience. One interviewee (the cluster manager) mentions that attention is given to risks with large probabilities of occurring. How EW related signs are treated also seems to differ based on the project phase. In each phase, different aspects are mentioned as most important and this changes the perception of what is important to take into account. The tender phase is compared to the project phase for example. As the tender phase aims at delivering a winning tender bid, most focus is on main requirements and functionality of the tender design. Execution based uncertainty tends to be neglected here, while they can become problematic during execution.

An example of an often experienced problem that appears when starting the project phase is uncertainty on the exact needs of the client for a certain project, about what should be included and what not. Difficult here is that the tender bid of the contractor is set up as scarce as feasible to be able to win. The client however expects "more than minimal requirements" and this gap needs to be bridged somehow for the client to be satisfied. This could be used as an EW sign. In projects, according to what the interviewees said, it seems that there is more formal attention for the client-contractor relationship to prevent disagreement, than for the functioning of the team to enable effective escalation.

An escalation model is not recognised by the interviewees as being made specifically for each project. When there is no escalation model made, the organogram is used to determine the path of where responsibilities for problems lie. In the experience of the system engineer: "Signals are rarely send to someone more than one rank away in the organogram."

Team culture, risk sensitivity of project members and individual experience are mentioned by the cluster manager and system engineer as decisive for how is acted on problems in practice.

4.3 Conclusion of the exploration of the construction organisation level

After exploring the construction organisation level, the second sub question can be answered:

Q2 *How is the response to Early Warning signs influenced by the organisational level?*

It can be concluded that the current management system of the construction organisation for projects does not contain steps towards facilitating responding to Early Warning signs. Most evident is the lack of practices described in the business management system to collect aspects related to soft EW signs. There is also little attention for structuring a response to a signal made lower in the organisation. Individuals in a project can report concerns, but how and to whom is open to own interpretation of the individual sending and receiving the concern. A distinction between system-basis and cultural-based behaviour, found by Williams et al. (2012) to be important for responding to EW signs, is also not found in PMI.

Apart from missing features, the current system also seems to have flaws. Process owners in the business management system, can fail to review their process multiple times. This can give risk of neglecting certain parts of the PMI for a long period. Internal control is in theory also mentioned as weak point of an EW procedure in general (Williams et al., 2012), as it is often not done critically enough.

By not describing a concrete plan to identify or use EW signs in PMI, there seems to be a lack of preparedness at the construction organisation. Unpreparedness is mentioned by Holopainen & Toivonen (2012) as contributor to project failure.

An overview of factors and barriers that influence the response to Early Warning related issues mentioned by personnel from construction organisation level is made. They are mentioned as influential for reactions to unexpected and/or unwanted events by the interviewees. In literature, these factors and barriers are mentioned to influence the response to EW signs, as they overlap with findings from Chapter 3. The factors and barriers are structured according to the OB theory levels as described in Section 3.7. PMI seems to focus on the organisation and project level, while the interviewees mentioned mostly factors and barriers on team and individual level.

<u>Organisational field</u>

- Procedures and protocols on how to act on or react to unexpected events
- Data collection from past projects

<u>Project level</u>

- Data collection, accessing, and storing during the project
- Reviewing a completed project and reflecting on it

<u>Team level</u>

- Team culture (e.g. openness)
- Team composition (balancing individual characteristics such as risk perception and expertise)

<u>Individual level</u>

- Experience and expertise (knowledge, insight, intuition)
- Individual characteristics: risk perception (risk taking or averse), pro-active behaviour

5 Case study: identification and response to EW signs in construction projects

The sub question answered in this chapter is: "What mechanisms influence the response to Early Warning signs in projects?". To answer this sub question, a case study is conducted.

Section 5.1 describes the goal of the case study, the three selected projects, data and interviewees. Section 5.2 describes the findings from case A, Section 5.3 describes the findings from case B, and Section 5.4 describes the findings from case C. Section 5.5 compares and analyses findings from all cases to find mechanisms that influence the response to EW signs. Section 5.6 concludes this chapter by answering the sub question.

5.1 Approach

5.1.1 Goal

The goal of the case study is to find mechanisms that are linked to the response to Early Warning signs in construction projects from practice. Three projects are part of the case study.

5.1.2 Case study selection, retrieved data per project and interviewee selection

Following the selection protocol described in Section 2.3.3, three construction projects are selected for the case study. Table 6 shows the characteristics of the selected projects for the case study and the retrieved data per case.

Table 6. Case study selection and retrieved data per case

Case	A	B	C
Project type	Development of public transportation infrastructure	Redevelopment of public transportation infrastructure	Infrastructure demolition and development
Selected event	CSM wall design changes	Instability of light rail foundation, and installing cables in the ground	Washout of Fundex foundation piles
Characteristics	DB contract, partially complex	DB contract, partially complex	FIDIC Yellow Book contract, many different stakeholders
Result of the project	Ongoing, time delay and cost impact	Finished, good (financial) results	Finished, good (financial) results
Sub-contractors involved in event of interest?	Yes	No	Yes
Data gathered	Progress reports, Organogram	Progress reports, Organogram	Meeting reports, Organogram, Reflection documents
Number of interviewees	5	5	5
Selected interviewees	A1: Project manager, A2: Manager risk & contracts, A3: Steering committee member, A4: Manager project control & planning A5: Civil work planner	B1: Project manager B2: Technical manager B3: Steering committee member B4: Risk manager B5: Manager work preparation	C1: Project manager's right-hand man C2: Design manager C3: Construction engineer C4: Stakeholder manager C5: Risk manager

5.1.3 Case study protocol

For each selected project, the same approach is applied. Interviews conducted at each project are in-depth, loosely structured interviews. Questions regarding what went wrong, whether there were signals of this problem, the persons who reacted to these signals and in which way, are of importance. Appendix B contains the general interview protocol used for the case study interviews. The interview questions are formulated with the aim of forming a coherent field of details from the interviewee of all aspects and details related to the cases of interest. After an introduction of the research and the interviewee, questions regarding what problems and unexpected events occurred in the project are asked. Further questions zoom in on these specific situations in order to find out more details about what exactly was done to resolve the problem.

As described in Section 2.3.3, the interview transcriptions were coded using closed (deductive) codes from the theoretical framework from Chapter 3, supplemented by open (inductive) codes that emerged from the interview data. The result of the coding process, the codebook, can be seen in table 7. The codes and citations from the transcripts are used to analyse the case events. Codes that repeat within a case draw attention, however the amount of times a code is mentioned should not be decisive in analysis the case. The effect of a code on the project outcome is more important.

Table 7 contains the results of the data coding process. Appendix C includes the coding results for each individual interviewee. The dark grey lines in table 7 show the OB theory levels that are used to structure the codes and themes. Themes are shaded light grey in the table. Themes describe an overlapping subject of the codes that fit within a theme. The most prominent codes are shown in the white rows in the table. Inductive codes in the codebook, gathered from literature, that were not applicable to the cases are not removed and can also be recognised in table 7.

To decide what codes and themes fit into what level of OB theory, definitions and descriptions from the study of Li et al. (2019) were followed. Actions that can be accounted to an individual (such as the behaviour of the project manager) are mentioned as part of the individual level. Concepts such as communication, where at least two people are needed for it to make sense, are fitted in higher levels. A broad code could fit in multiple levels, however the division serves as aid for data analysis, not as main source to derive conclusions from directly.

Table 7. Coding of interview data per project

Codes	Case A	Case B	Case C
1 : Level 1 Individual			
2 : Individual behaviour	7	4	2
3 : Lack of weak signal mind-set and sensitivity	5	1	0
4 : Sign of weak signal mind-set	2	2	0
5 : Lack of experience	2	1	1
6 : Lack of expertise	0	0	0
7 : Manager characteristics	2	3	5
8 : Negative for EW behaviour	0	2	3
9 : Positive for EW behaviour	2	1	2
10 : Level 2 Team/group			
11 : Communication	5	1	3
12 : Fragmentation of information	2	0	1
13 : Positive for EW response	3	1	2
14 : Error found by project team	0	5	1
15 : Error in design calculation not noticed	3	0	0
16 : Group collaboration	3	6	19
17 : Negative for EW response	1	3	5
18 : Positive for EW response	2	1	4
19 : Group culture	9	13	7
20 : Starting construction prior to approval or agreement of client	0	3	0
21 : Lack of commitment as team	1	3	0
22 : Optimism bias	0	3	3
23 : Reluctant or afraid to report issues and thoughts	3	1	1
24 : Sticking to their own idea or assumption	0	2	2
25 : Missing competence as project team	0	1	1
26 : Not feeling responsible	0	5	6
27 : Interacting with hard vs. soft data	8	0	4
28 : Project management issues	1	0	4
29 : Planning issues	0	0	0
30 : Project control and reporting issues	1	0	1
31 : Subcontractor influences EW behaviour	12	2	6
32 : Negative	8	2	0
33 : Blind trust in subcontractor	4	2	0
34 : Irritation because of mistake in subcontractor's design	3	0	0
35 : Subcontractor did not share issues or thoughts	1	0	0
36 : Positive	0	0	6
37 : Error was found by subcontractor	0	0	6
38 : Error found by subcontractor using standard protocol	0	0	1
39 : Level 3 Project			
40 : Collaboration between groups	1	0	6
41 : Importance of stakeholder management at construction project	0	0	5
42 : Complexity of techniques	13	0	3
43 : Subcontractor is unable to perform complex technique	7	0	0
44 : Uncertainty underground	1	0	0
45 : Financial pressure	3	0	0
46 : Influence of client	0	6	19
47 : Lack of expertise client	0	2	1
48 : Client does not inform EW related information	0	0	5
49 : Client was informed by contrractor	0	4	2
50 : Delegated client acts on behalf of client	0	0	7
51 : Client mistrusts contractor regarding claiming extra costs	0	0	4
52 : Preparedness before starting project	8	11	4
53 : Negative influence of transition from tender to project executio	5	8	4
54 : Problem was not recognised during tender	0	0	1
55 : Project team composition	7	5	3
56 : Project structure	2	1	0
57 : Special / unusual contract type	0	0	8
58 : Disagreement between parties on contract interpretation	0	0	3
59 : Steering committee	3	4	1
60 : Time pressure	6	4	5
61 : Time pressure during tender	2	0	1
62 : Uncertainty avoidance	0	0	1
63 : Unclear documentation	8	6	5
64 : Level 4 Organisational field			
65 : Client with unclear expectations and role	0	0	0
66 : Control imposed by stakeholders	1	1	5
67 : Effects of politics on projects	1	0	0
68 : Lessons learned	6	8	1
69 : Best practice applied from previous project	0	2	0
70 : Lack of learning from previous projects	6	6	1
71 : High change over of personnel during project	2	0	1
72 : Learning as individual not as organization	5	0	1
73 : No trust in good project result by people in organization	0	4	0

5.2 Case A

5.2.1 Case introduction

Case A consists of a DB contract awarded to the contractor. It is an infrastructure project in the Netherlands. Among others, the project includes the construction of infrastructure for public transport. A complex part of this project is the creation of an underpass for busses below street level. This passage had to be dug out close to the facades of houses and for the support of the building pit, a complex type of dam wall was needed. The design and application of a Cutter Soil Mix (CSM) system is selected as event of interest for this project. As this system is known to be technically complex and caused cost overruns, this event was highlighted by the interviewees.

5.2.2 Description of event A

The strict requirements regarding soil movement due to the construction of the building pit at case A, set by the client in the tender, were missed by the contractor and subcontractor. Event A describes the outcome of this mistake. As a result, the design of the CSM wall did not contain these strict requirements. This error was noticed by a designer during the early design phase, after the tender was awarded to the contractor. The manager project control explained:

> “The design for the CSM wall was made in collaboration with a subcontractor. We knew that the CSM wall would be difficult to design, but we trusted the subcontractor with his design. Never did we expect that the design would be this wrong.” (manager project control, A4)

When a designer noticed the mistake during the early design phase, he rechecked his calculations and reported his findings to the design manager, who contacted the project manager soon after. The team culture was mentioned to allow for colleagues to be approached easily, for example the civil planner (A5) and manager project control (A4) stated:

> “You can easily walk into each other's office and communication lines are very short here”. (civil planner, A5)

> “If we were worried about something, we could put it right to the manager”. (manager project control, A4)

It was already too late to discuss the strictness of the requirements with the client. A member of the steering committee (A3) and contract manager (A2) stated:

> “They turned out to be so strict, we could hardly realise them in practice. We should have talked about these strict norms with the client earlier”. (steering committee member, A3)

> “Lead times were important: we got a year to design something. If you find out halfway through that the CSM method is expensive, you can no longer switch to a diaphragm wall. You already have sunken costs for this design and you don't have time for a new design”. (contract manager, A2)

Looking back, these requirements should have been used as EW sign, but were missed. The manager project control (A4) concludes that the strict norms were not taken into account enough. He mentions:

> “In the tender they must have known about these strict norms, in hindsight they should have paid more attention to these norms in the tender”. (manager project control, A4)

A reason for missing this as EW sign was given by the civil planner (A5) and the project manager (A1):

> “The design was not outlined far enough in the tender to realize the impact of the strict requirements. Then perhaps you should have done all those calculations in the tender. But the question is: how much do you already calculate in the tender, as you are not yet making a complete design.” (civil planner, A5)

> “If there had been more time available in the tender phase, and more personnel available, we could have analysed the design in more detail. Then we could have found the error in the design.” (project manager, A1)

When the subcontractor tried to redesign the CSM wall to cope with the strict requirements, time delays and cost overruns emerged. The costs of materials that were actually needed for the CSM wall to stay within the strict requirements of the client were a lot higher than planned initially.

The sub-contractor stated that they were not able to construct the CSM wall in line with the strict requirements and left the project. The manager project control (A4) stated:

> “The CSM wall was discounted by the sub-contractor. The designed wall kept getting thicker, and the cost estimate kept increasing, until the sub-contractor left the project as they were unable to design and construct the CSM-wall”. (manager project control, A4)

Looking back, the lack expertise and knowledge of the subcontractor were mentioned by the project manager (A1) as something that could have been known. He explained that the first sub-contractor was not able to design and construct the technically complex CSM-wall for this project and that this could have been known:

> “These kinds of subcontractors, who make CSM-walls, are generally not used to making such sophisticated designs as this one, so we should have been very careful with whom we contracted”.

The contractor however expected no problems with the design of the subcontractor during the start of the project. They assumed that the subcontractor had full (legal) responsibility for delivering a good design. The expectation of not being responsible themselves, and because they were not aware of the incompetence of the subcontractor lead to the project team trusting the initial design of the sub-contractor. The manager project control stated (A4):

> “The party we had on board had promised in the tender that they would go along integrally, as a full partner, not as a subcontractor. And they started acting as a subcontractor from day 1, so that is a substantial difference. It turned out that the sub-contractor’s promised responsibility as full partner was not mentioned in the contract.”

After the subcontractor left, a second subcontractor was approached. This was a larger company, that was able to build the CSM wall. The design of the CSM wall was made by the contractor itself. There was a high time pressure to start building the CSM wall and because of this the new contract with the second subcontractor was formalised in one month. During construction it turned out that

this contract did not cover all aspects relevant for the execution. This caused friction between the second subcontractor and the contractor, but was resolved by a realistic dialogue. The main point of discussion was who should pay for the impact of changing the CSM wall design on the other parts of the design, mainly the extra strut frames needed in-between the CSM walls for stabilisation.

The design of the strut frame was done by the second subcontractor. That party estimated they would need 1 to 2 weeks per calculation section of the construction pit. In reality it turned out they needed at least 4 weeks per calculation, for a total of around 10 sections. This extreme delay was only noticed when the milestone of completing the whole design was only 1 month away. Only when this deadline was very close, and associated extra costs of failing to reach that milestone in time were clear, permission was given by the steering committee to create capacity to help complete the design. The manager project control (A4) mentioned that this action only costed time while not generating any cost reductions, which he knew was not even possible anyway in this case:

> "The steering committee said that our solution was too expensive and declined it. We already knew that no other solution was possible, so at the next meeting we proposed the same solution for 500 euro cheaper. They agreed with the solution anyway, that is common behaviour of the steering committee".

5.2.3 Case A findings

Most influential codes found in the case event:

<u>Individual level</u>

- (Lack of) proactivity to report or raise questions
- (Lack of) technical knowledge

<u>Team level</u>

- Uncommonly strict norms
- Technical complexity
- Team culture and internal collaboration
- Time pressure

<u>Project level</u>

- Communication
- Collaboration with teams from other organisations
    - Dependence on and trust in sub-contractor

<u>Organisational field</u>

- (Lack of) formalising agreements with first subcontractor
- Incomplete contract with second subcontractor

5.3 Case B

5.3.1 Case introduction

Case B consists of the renovation and construction of a light rail track and stations in the Netherlands by the contractor as part of a DB contract. The stability of the underground for the new light rail plans turned out to be a huge issue. Because this had a large impact on the project, this event is highlighted as case B1.

During the interviews, a second event in this case was mentioned as influential on the end result of the project: the quality control while placing underground cables was inadequate. Case B2 is an event mentioned in detail by the risk manager of the case. As it shows a clear EW sign and a response on that sign, the case is part of this research. This event is explained in a separate sub section.

The case in general was further characterized by the short time available to prepare and execute the project. In the initial stages of the project, within the construction organisation, the division executing the project internally changed. The division that wanted to submit a tender bid estimated the project to be too risky, while another division disagreed and took over.

5.3.2 Description of event B1

Event B1 consists of the project team being unaware of porosity issues in the underground. The instability of the surface underneath the light rail track was not expected by the contractor during the tender phase. Trial slots in the field were made for the placement of new cabling components needed for the rail. Here a first indication of the issue of porous soil emerged. This happened at the start of the execution phase of the project. The risk manager (B4) said:

> “In some places where trial slots had been dug, the groundwater was already rising, and the ground immediately became soggy. Nearly swampy you could say.” (risk manager, B4)

> “You would think that during the tender phase some soil research would have been done already. However, we encountered several large sections of track that were porous, that we did not know about.” (risk manager, B4)

The information on ground porosity was missed as EW sign. When the project manager heard of possible porosity issues via the construction workers, the project manager decided to perform extra ground surveys along the track. Some interviewees mentioned that they assumed that the underground was stable, as another light rail already drove on the same soil for quite some time already. However, according to the information in the tender, it was clear that the new light rail would get much heavier carriages. This means that the then current load of the light rail could not have been representative for the new light rail anyway. The ground surveys returned a more problematic result than expected, as the manager work preparation (B5) stated:

> “We all had a feeling that there would not be such a large issue with the porosity of the underground. The old light rail track here was already in use for multiple decades. We were surprised by the negative outcome of the ground surveys. The impact that a newer and heavier tram would have on the underground was larger than expected.” (manager work preparation, B5)

> "It (the problem) was underestimated because it is a relatively new problem. By upgrading rail connections, recently the restricted limits of the old infrastructure became a bigger problem countrywide" (manager work preparation, B5)

The client influenced the progress of the project by granting permits late and when the unstable underground was brought up, they demanded several calculations to be redone. The technical manager said:

> "The client did not want to admit there was a problem, they wanted us to do extra calculations, however they all turned out negative: we all really had a problem." (technical manager, B2)

Multiple interviewees mention that they expected that the client would have given them information on the condition of the soil if it could become an issue for the project. The client however did not expected ground porosity to be an issue either. The project manager (B1) and technical manager (B2) said:

> "It was not our responsibility to check the soil consistency as it was outside our project scope to make sure that the ground was stable enough for the new development plans." (project manager, B1)

> "During the tender we did not assume that the ground underneath the track would become an issue. The tender contract did not even state how mitigating measures would be contracted later, so we assumed that no mitigating measures would be needed anyway." (technical manager, B2)

Another reason mentioned by interviewees for not recognizing the issue earlier was that they assumed that the client was responsible for ground related information according to the contract. If the information was incorrect or missing, it contractually would not be the responsibility of the contractor they assumed. However, another interviewee mentioned the switching of the project between divisions during the tender phase as reason that no attention was paid to this aspect. The chaotic switch of executive division for this project caused the deadline for asking for this type of information to be missed. The risk manager (B4) told:

> "There were a few formal rounds to ask the client for more information, bidders in the tender can submit a 'note of information'. However, during the tender phase, we were in a standstill for three weeks as it was uncertain whether we would continue with the bid. In the end another business unit took over control and we continued. I think we missed the opportunity to ask for this information in this chaotic period." (risk manager, B4)

Backward looking, when renovating old track, a lack of knowledge on soil stability should have been used as EW sign. Afterwards some interviewees said they will make sure to check the stability of the underground in the future for every rail project they will work on. Lacking earlier experiences, they were not aware of the problems that could be caused by not having this information early on. This is an indication that the current lessons learned protocol was not effective to save this project from losing a significant portion of the profit margin. It seems that it was missed because of a lack of experience with similar projects. The project manager and risk manager (B4) said:

> "We did not even know ground instability would become an issue, it really was our blind spot." (project manager, B1)

> "After [case B], I always, always, make sure that sufficient ground surveys are conducted before starting with a rail project!" (risk manager, B4)

In the end, the design was changed based on the ground survey results and where necessary mitigating measures were proposed to the client by the contractor.

5.3.3 Description of event B2

Event B2 describes the response to an EW sign brought up by the risk manager in case B. A lot of piping and cables needed to be placed in the ground along the light rail track. The client had made clear beforehand that they wanted to know in what location the cables would be placed exactly. During the placement of the piping and cables however, the exact locations were not tracked sufficiently. The risk manager warned of the possible consequences of not tracking these locations: the client's demand could not be met otherwise. In this case, not taking photos while placing cables in the ground was reported as an EW sign. Verification management was not conducted properly. The client would not accept the end result of the project when the cable placement underground was unknown to them. The risk manager mentioned:

> "There are all kinds of checks and balances that have to be carried out, but no photos were taken of the situation at that moment. The client was already beeping about it, because they wanted to have those photos as prove of where the cables were placed." (risk manager, B4)

The reactions to the EW sign sent by the risk manager to the project team dismissive. The EW sign was seen as unwanted critique, and was not taken seriously. He explained:

> "My warning was not taken seriously. The construction workers wanted to place all cables as fast as possible, just to be done with it, and my message was laughed out of the room. But that is not how it should work. The ones running the piping and the ones pulling the threads through the piping should communicate with each other. The manager project execution should make sure that this communication takes place, but he was inexperienced and seemed to did not know what to do…" (risk manager, B4)

> "Negative comments… They (the construction workers) did not really want to hear them. They thought they had everything under control and did not like critique. I missed people feeling responsible for the project as a whole, instead they focused on their own little pillar." (risk manager, B4)

As a reason for the lack of attention to quality control in a project, multiple reasons are mentioned by the interviewees. The project manager mentioned team culture as main reason:

> "A lack of internal quality assurance is part of the culture in the rail infrastructure in general." (project manager, B1)

Inexperienced project workers were influenced by other personnel in their behaviour, according to the risk manager:

> "There were also young guys in the team, they were told they had to do their inspection quickly, even if it would harm the quality, and they also acted like they did not put quality in the first place… I think that is outrageous." (risk manager, B4)

A steering committee member mentions the preference for quick solutions instead of addressing issues thoroughly in construction teams:

> There is a preference for quick fixes instead of actually understanding the problem causes. "Fixing it quick, then everything will be okay again." This sometimes leads to the construction team fixing problems that were not even ours in the first place." (steering committee member, B3)

The influence of the management team and the project manager on the issue was mentioned as insufficient in the situation:

> "The project manager did not like a lot of extra tearing and friction in the team, and they (the managers) did not do anything about the lack of test results. The manager was not someone who wanted to cause a conflict situation, while it was needed to improve quality." (risk manager, B4)

Because of a period of interruption of public transport that was needed to complete the track, a strict deadline was set to finish certain parts of the project. Trying to finish before the deadline, under time pressure, is mentioned as contributing to the behaviour in this case in general, but not related to this specific event.

The public transport system at the moment is in operation, but there are still issues locating where the cables are placed. Because at first the EW sign was ignored, the damage had already been done. Eventually the steering committee intervened to try to restore the situation. Construction designs were not closely followed by the construction workers placing the cables. Cables seem to be placed outside of piping that was installed before and was designed to protect the cables from pressure from the light rail track. Until this issue is resolved, the project cannot be completed.

5.3.4 Case B findings

Most influential codes found in the case events:

<u>Individual level</u>

- Individual characteristics: experience, being (not) afraid to speak up
- Project manager's behaviour of preventing conflict

<u>Team level</u>

- Team culture (stubbornness regarding formal protocols and registering details)
- Collaboration between groups

<u>Project level</u>

- Time pressure
- Management shies away from conflicts
- Response mechanism to escalations via steering committee

<u>Organisational field</u>

- Lack of (effective) lessons learned protocol

5.4 Case C

5.4.1 Case introduction

Case C consists of the construction of access roads, (re)moving old infrastructure, installing large amounts of wiring, and other facilities at a busy transportation hub in the Netherlands. The location of this project is surrounded by economically important activities, and a lot of stakeholders were involved because of this. The event of interest at this project is the structural failure of foundation piles. The type of foundation piles in the design, were issued in the design by the (delegated) client. As this had a large impact of the outcome of the project, this case was selected. The type of contract used in this case was FIDIC Yellow Book, a delegated client was supervising the project, and the design was largely already made by another party, commissioned by the delegated client.

5.4.2 Description of event C

Case C was located near a busy transport hub and the contract stated that the surrounding area should be hindered as little as possible during construction. Because of this, an overview of the surroundings of the project was made three months before the project would start, during which informal information from a neighbouring construction project reached the stakeholder manager of the contractor. This neighbouring project had issues with the construction of foundation piles, as for an unknown reason their piles were structurally unsound. The stakeholder manager told:

> "Next to our project, about 500 meters away, another party was constructing a parking garage. They had issues with their foundation piles. We received access to a report they made, and it turned out that they used a foundation pile technique relatively similar to what we wanted to use." (stakeholder manager, C4)

The information at that moment was identified and used by the risk manager of the case as EW sign for possible foundation pile failure during construction. He discussed the information in the project management team, initially without much effect, as the warning was not taken seriously:

> "After I found out, I organised a session in the project team in which I asked: how big is the chance that this will happen to us? Should we think of another construction method or not? However, they were quite laconic about this at first." (risk manager, C5)

The information that a nearby project with the same pile-type had problems was deliberately not used by the management team of case C to create a clear action plan early on. There was not enough evidence for failure to consider alternatives according to the design manager.

> "We warned the client. But we did not know what exactly happened at the other project, we did not know whether it would become a problem for us as well, as we could not do much more than warning the client. Doing more was not our responsibility." (design manager, C2)

The design manager mentioned the lack of clear communication and lack of pro-active behaviour in this process:

> "The communication in the project was good, but messy, not very structured. There was no clear action plan towards gathering data on the possible problems and underlying causes. (…)

> There was a lack of proactivity in actively managing risks of the new foundation piles" (design manager, C2)

The behaviour of the project was also mentioned as influencing the response to the EW sign. The project managers right-hand man (C1) described his behaviour as: "focused on: keep on going, as long as no actual failure occurs".

The risk manager by himself then decided to involve ground specialists, to ask for their expertise in this situation. This at first was not appreciated by the management team:

> "It was not seen as a problem, everyone was opportunistic instead of realistic. Because of that, I involved foundation experts in the project for their expertise and experience, to let them look at the situation and the information we had available. (…) Some people in the project thought I overstepped by asking specialists from outside the project for their input, but in the end they agreed that it was a good choice to invite them" (risk manager, C5)

The experts concluded that here was no closed evidence that the type of foundation piles in the design (chosen by the client) would likely fail if constructed.

The project team did inform the delegated client on the knowledge they had. The delegated client was suspicious about the information on possible pile failure, as it could have been a tactic of the project team to claim extra work at the expense of the client. Informing the client was a contractual obligation of the contractor, as the project manager's right-hand man explained:

> "We were obligated to inform the delegated client, that was specified in the contract as the advanced warnings principal. The client then had to react, and if they do not react you can continue with your own process. When something still goes wrong later, the client has to compensate you for that." (project manager's right-hand man, C1)

> "The contract manager and project manager mainly communicated this issue with the delegated client. The delegated client informed us that we just needed to continue, so we did just that." (design manager, C2)

In total, a couple hundred piles needed to be constructed according to the design. Because of capacity issues due to time delay, the construction organisation needed to hire a subcontractor for this project for the construction of the foundation piles. No monitoring was done because of the costs associated with that. The design manager told:

> "We could monitor the progress, however that would have costed us money, while it was contractually not our responsibility to monitor it. Backward looking, we should have demanded more monitoring from the client in this case." (design manager, C2)

The subcontractor eventually found bubbles on top of newly constructed piles, after ten piles were constructed, an indication of structural failure of the piles. However, the subcontractor continued, and as they were experts on foundation piles, their decision was not questioned.

> "After a couple foundation piles were constructed, we already saw something was wrong." (stakeholder manager, C4)

> "The subcontractor was a real expert in cast in place piles. We expected pro-active behaviour from them. As long as they would continue, there was no large issue, we assumed." (design manager, C2).

The management team of the contractor at the case decided to formulate mitigating measures, for example regarding the amount or the speed of piles constructed, to be able to monitor ground and pile conditions before, during, and after pile construction. As the applied working methods and mitigating measures implemented at each pile where not registered properly and not executed strict, no information was available on whether the mitigating measures helped or not:

> "Assessments of the piles were not filled in correctly or completely" (design manager, C2)

> "The subcontractor did not document their work properly, so the origin of the pile failure was unknown to us" (project manager's right-hand man, C1)

The incomplete assessments made the client and the contractor doubt about the actual origins of the failing foundation piles. Especially the client did not want to believe it was caused by the soil, instead of by bad work practices for example. They wanted the workers to continue. The contractor then decided to assign two inspectors to the task of monitoring the pile construction process. This task was not specified by the PMI quality management earlier:

> "At that moment we made our quality manager responsible for the entire inspection on the construction site. So he got 2 employees who had to help keep the inspections on track and check lists. This was insufficiently described in the PMI quality management." (project manager's right-hand man, C1)

After the construction of the hundredth pile, the subcontractor quitted the project because they could not guarantee the quality of the piles. The delegated client still took a defensive attitude and did not want to talk about possible design changes after the subcontractor left the project.

> "We concluded that the problem was caused by the bedrock. Something is happening that we warned you (the client) about with this type of pile. If nothing can be done about it from the implementation point of view, then it is a problem for the client. Because you prescribed those poles. And that's something they didn't want to hear." (construction engineer, C3)

Eventually, a director of the contractor escalated this problem directly to the client itself, instead of communicating via the delegated client. This made the difference, and the contractor was given permission to place and charge a more expensive pile type. The reason for this escalation was mainly the huge financial result of the case that was at stake:

> "In the end, we looked at our higher management. We said: come along with us to the client, because this discussion about piles involves a lot of money." (stakeholder manager, C4)

As reason for the management team initially not reacting to the EW sign, most interviewees mention the FIDIC Yellow Book type of contract. They were convinced that, according to the contract, they had to construct the specific pile type as dictated by the client, despite the information available on potential pile failure. If the contractor would have decided to choose another (more expensive) type

of constructing piles with the evidence available at that time, they would have had to pay all extra costs themselves according to the contract:

> "The client was the one who had the control over the situation to make decision according to the contract, not us. They were the ones who could decide what type of piles we needed to construct, we could not change the situation on our own without having to pay the millions of extra costs for a new pile type" (construction engineer, C3)

> "The responsibilities about the type of discussion we had were clearly stated in the contract." (stakeholder manager, C4)

5.4.3 Case C findings

Most influential codes found in the case event:

Individual level
- Project manager attitude
- (Informal) stakeholder knowledge of project nearby

Team level
- Communication
- Team culture: stubbornness towards acting on pile failure information

Project level
- Contractual agreement above acting in 'best for project' practice
- Distrust from delegated client towards contractor
- Responsibility/ability of contractor to convince client of impossible pile type

Organisational field
- Escalating pile failure information to the client

5.5 Summary and comparison of the cases

Table 8 presents a summary of the case descriptions. Comparing the case event descriptions, two different underlying causes that were decisive for the response to EW signs in the case events seem to stand out. The main underlying causes for the response (or lack of response) to EW signs also seem to emerge by analysing the 'main lessons' column in table 8. This column points out what was not done properly during the events regarding the negative outcomes.

Two different reasons for not properly responding to EW signs in the case events appear from the data. Firstly, the way information flows in case A and case B were organised seems to have prevented EW signs from being identified. Secondly, the impact of group culture and interaction within the project team in case B and C seems to have hindered the response to EW signs.

Another recurring theme was found, seemingly separate from the earlier mentioned underlying causes, and also stands out: in multiple cases behaviour regarding the response to EW signs seemed to be influenced by interpretations of agreements, leading to expectations and trust. This in the end resulted in a restricted response to EW signs.

These are now further explained.

Table 8. Summary of the case events

Case event	Event	Contract-type	Moment of EW sign	EW sign and origin	Mediating / Moderating variables	Response to EW sign	Effect / outcome	Main lessons from the case
A	CSM wall design of subcontractor does not comply to the client's strict deflection requirements. First sub-contractor said they would join the project as 'partner', but left because of design issues.	DB-contract	(Early) design phase (after tender)	Very strict deflection requirements CSM wall noticed *after* tender. Designer identifies mistake in design.	Time pressure and trust in subcontractor's design were mentioned as reason for not finding the mistake in the design earlier. Incompleteness of contract: 'partner' statement first subcontractor misses.	Designer recalculates design to be sure, reports findings to design manager. New design is made. Second subcontractor brought in, however not all design respon-sibilities covered	Adjusted design requires more steel (more costs), and increased complexity: first subcontractor was unable to construct it (expertise and scale problem).	Background check subcon-tractor needed Evaluating design and progress of designs sub-contractor Check contract for completeness
B1	Porosity ground not as expected by contractor. Project switched between internal divisions of contractor, missing moment to require information. Client never thought porosity would be an issue.	DB-contract	Start of execu-tion phase	Porosity ground discovered by operator during tests in field for cable placement.	Porosity never considered as issue (lack of knowledge). Contractor's interpretation of contract that client would be responsible for stable ground lead to little attention for potential issues.	No early response, as porosity was never considered a problem. Eventually: Extra tests into ground conditions at construction site.	Adjusted design based on outcome of tests. Client demanded recalculations, initially did not trust the results.	Timely requiring information on ground conditions during tender. Testing ground conditions was no regular procedure.
B2	Quality control not executed sufficiently.	DB-contract	During execu-tion phase	Risk manager reports feelings on lack of quality control to management team, as it is needed for internal purposes and client is interested in them.	A lack of collaboration between groups (not feeling responsible) Team culture (lack of attention to quality). Underestimating impact ("it will all be fine-mentality") Preference for quick fixes, without looking at consequences. Influence of the project manager: he did not want friction in the team.	Warning not taken seriously intitially. Very late EW response to improve inspections, but damage was already done. Eventually manager and steering com-mittee convinced team to act according to quality control.	No information of what cables were placed where. Need to locate cables by digging them up. More strictly monitoring quality control, conform internal quality system.	Important to react faster to prevent further damages. Monitoring whether quality protocol was followed was substandard. Be stricter on personnel ignoring quality control.
C	Foundation piles structurally unsound. No action is taken while this is known. Much debate and disagreement with 'delegated client' on contract regarding costs and responsibilities of failing piles.	FIDIC Yel-low Book	Three months before start of execu-tion phase	Stakeholder manager receives information of a nearby project, using similar piles as planned at case C, were major problems occurred During execution: subcontractor observes air bubbles in freshly poured concrete piles.	'Optimistic' team just starts constructing piles (little contrary opinions). Unclear cause of failure of piles because of poorly tracked construction conditions. Disagreement with delegated client on responsibilities influences the contractors behaviour. Delegated client distrusts contractor: they assume they only wants to claim extra costs.	Risk manager hires foundation experts before construction for research (while team found hiring them unnecessary) Experts say they cannot predict whether failure will occur. During constructing failing piles, the manager wants to continue to prevent time delays.	Trade-off matrix made, decision to continue but try mitigating measures. Subcontractor of piles cannot guarantee pile quality and stops further construction. Debate with delegated client is fruitless, director from contractor now escalates to client directly.	Earlier intervention: planning a strategy when and how to react and intervene. Consider whether/when the client needs to be involved in this process. Better tracking construction conditions subcontractor.

5.5.1 Lack of information flow prevents identification of Early Warning signs

Event A and event B1 both show that an obstruction in the information flow in the project caused that there was no possibility to identify an EW sign for the project team. In these cases as a whole there were possibilities to identify EW signs, but in these specific events information to base a decision on was missing. The cause of the underlying problem seems to be the organisation of the information system, that prescribes what information should be stored and how it should be handled. Unaware personnel cannot react to information they do not receive. Interventions as response to later signals in these cases show that the reaction mechanism in these cases did function. Information flow between divisions and between different phases of a project seem to be most problematic.

At event A, the strict deflection requirements for the CSM wall, that should have been known during the tender, were missed and not part of the initial design of the CSM wall, after the tender was won. Somehow that information did not reach the proper destination and was not considered important enough to be transferred more careful between phases. A specific technique was chosen in the tender design, without thinking about the enormous impact it could have if this technique would not to be suitable in practice. An EW sign regarding the unusual strict deflection requirements was not identified earlier, as the requirements were unknown by the project team at that time. As a result, the eventual warning sign sent was very late. Another example at this event is the project team being unaware of the lack of expertise and financial standing of the first subcontractor. Unawareness by the project team of this made it impossible for them to consider the potential consequences.

At event B1, the porosity of the ground was unknown to the project team until the execution phase began. As there was no requirement to gather this information and as no one thought it would become a problem, it could not be used as an EW sign. During the tender this project switched between internal divisions of the contractor. In this process the time frame to ask the client for information related to ground porosity was missed. The internal transfer of the project between divisions caused a lack of information during the rest of the preparation of the project.

Figure 9 visualises factors related to the underlying problem of not being able to identify an EW sign due to a lack of available information. These factors contribute to starting and executing a project with too little information available on potential problems from which EW signs could be identified. As not enough information is stored, new personnel starts with a knowledge gap. Personnel after the transition from tender to project phase lose information that stays behind in the tender database, or is never stored and forgotten. A lack of attention to future risks during the tender while losing information of why certain design decisions were made in the tender phase, makes it harder to identify and timely monitor EW signs later. Time pressure and the pressure to come up with a competitive tender offer are mentioned as reasons that little attention is paid to EW signs in the tender.

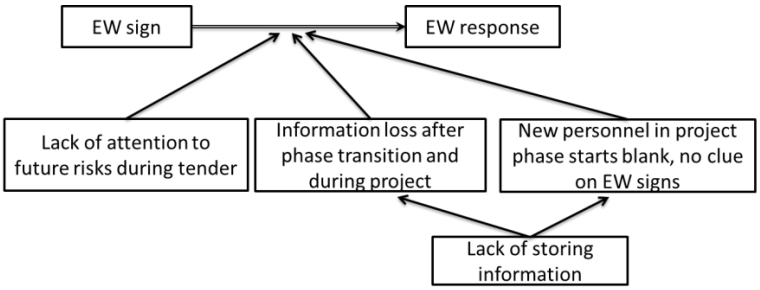

Figure 9. Lack of previously available information

5.5.2 Group culture and team interaction hinder response to Early Warning signs

In case B2 and case C both an EW sign was identified. Both events show that project culture and interaction within the project team influenced how was responded to these EW signs. In both cases an EW sign was shared to the project team immediately after identification and in both cases there was no immediate big response to the EW signs given by the project team.

The EW sign identified in case B2 by the risk manager was the lack of quality control conducted by workers on-site during the placement of the piping and cables. He saw this as an indication for a potential future problem of not knowing exactly where piping and cables were placed. The workers on-site did not feel the responsibility to attend all quality control procedures. The lack of attention to quality was mentioned as part of team culture. They had a mentality of believing that everything would work itself out. The workers preferred choosing quick fixes on-site instead of trying to understand the consequences of their work. In the management team, the project manager implied he did not want to increase the friction in the project team and did not intervene in the situation. Delaying the EW response worsened the outcome of the situation, as more data from the field was lost every day while not keeping track of piping placements. Eventually the pressure to act became too high after intervention of the steering committee, and the team now was instructed to follow the quality management protocol more tight.

In case C, informal information on the failure of foundation piles from a nearby project reached the stakeholder manager of case C, three months before the execution phase of the project started. This was reported in a project management meeting, but no interventions were planned after discussion the information. When the interviewee reflected on the process, the atmosphere during the meeting was described as too optimistic (C1). The absence of many contrary opinions made the team decide to not undertake action to the warning. The risk manager decided himself to ask a team of foundation experts for their advice, against the will of the management team as this was regarded as not needed. The experts did not find enough evidence from the nearby project to conclude pile failure would become an issue at case C too. However, soon after construction began, air bubbles were observed by the subcontractor who was construction the piles. The management team decided to continue, while applying some mitigating measures. Again, the team underestimated the impact of a warning sign. However, the measures applied were not documented properly and the cause of structural pile failure was still unknown. A large disagreement with the delegated client with an unresolved ending eventually led to a director from the contractor escalating to the direction of the client immediately. This provided a solution: changing the pile type in the design. In the meantime

already more than a hundred piles were already made and deemed unstable. An earlier intervention would have saved a lot of time and money.

Case B2 and case C show the impact of the team culture on not properly responding to the EW sign. At team level, EW signs were seemingly not taken seriously, as they were not used to develop a strategy or plan an intervention in the project. Not feeling responsible for the problems ones behaviour can cause later in the project can also be attached to this culture. The manager's aim of not delaying the project and as a consequence perhaps failing to reach certain milestones on time influenced how was responded to the EW signs as well. The potential importance of EW signs seems to be denied. This mechanism is visualised in figure 10.

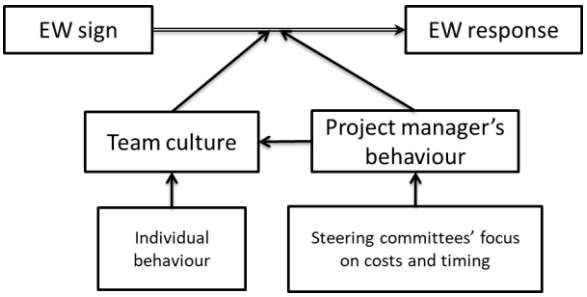

Figure 10. Collectively denying the importance of EW signs

In addition to the lack of anticipating EW signs on group level, a lack of awareness about potential issues on individual level also seems to influence the response to EW signs negatively, according to the case findings. Figure 11 visualises this mechanism. When someone is convinced that nothing wrong will happen, and underestimates the risk or impact of a situation, EW signs will be taken less seriously. Peer pressure in a team, as part of team culture, seems to influence the perception of risk of an individual. The collective "it will all be fine-mentality" in event B2 for example made individuals placing cables in the project underestimate the impact of not closely adhering to the quality control protocol during their work. Next to risk perceptions of individuals, overlooking EW signs also influences the response to EW signs. Mainly a lack of individual experience seems to have an impact, as not knowing what can go wrong makes it harder to identify something as an EW sign.

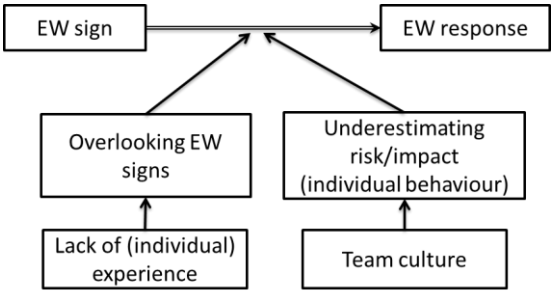

Figure 11. Lack of awareness about potential issues

5.5.3 Interpretations of agreements

Next to the two main underlying causes of not reacting to EW signs mentioned earlier (a lack of information flow, and the influence of group culture and team interaction), a third recurring theme seems to emerge from the data. The interpretations of agreements and expectations by a project team seems to influence how they react to EW signs.

In event A, not finding the mistake in the initial design of the CSM wall earlier was linked to trusting the first subcontractor who was held responsible for making the design.

In event B1, the project team did not actively try to find out whether the soil was suitable for the supporting the renovated track. One of the reasons mentioned for this was that they assumed it was not their responsibility to make sure the soil was suitable according to their interpretation of the contract.

In event C, a part of the project team assumed they could never change the foundation pile type, as the contract said they had to construct the design exactly as outlined by the client earlier. They trusted that the design would not include a pile type that would be impossible to construct and did not feel responsible to spend budget and time to find out whether the prescribed pile type was feasible to construct.

The trust or expectation of the project team regarding who does what, seems to influence the way they acted during the whole case, including the response to EW signs. Both in events where the influence of group culture and team interaction seem most problematic, and events where information flow issues in the organisation seem most problematic, the interpretation of contracts and agreements was mentioned as influential on behaviour. Figure 12 visualises this mechanism.

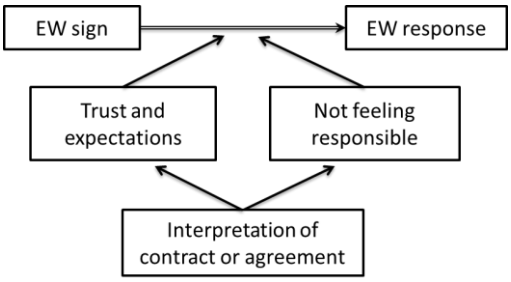

Figure 12. Interpretations of agreements

5.6 Conclusion of the case study

Sub question 3 can be answered.

Q3 *What mechanisms influence the response to Early Warning signs in projects?*

Comparing findings from four case events, two main underlying mechanisms appear to be found.

Firstly, the way the information flow at a project is organised seems to influence whether an EW sign can be identified. Information that was known or should have been known at one point can get lost and then cannot be used somewhere else in the project as EW sign. EW signs cannot be identified when information on possible future problems is not available. The way information is organised in a project, how it should be stored and how information can be accessed, are part of the underlying problem here.

Secondly, the impact of group culture and interaction in the project team hinders the response to EW signs. Once an EW sign is identified in a project, a response appears to not get formulated because of a collective denial of the importance of EW signs. From an individual level, people seem to overlook EW signs or underestimate the impact of the problem that an EW sign indicates could occur.

A third theme, that shows overlap with the first two mechanisms, repeatedly emerged from the data: The interpretation of agreements and expectations by a project team seems to influence how they behave in a project and react to EW signs. Trusting and expecting another party to finish something, or being convinced that another party is responsible for something, seems to result in a reduced attention for identifying and responding to EW signs related to the associated activities.

Table 9 presents the underlying mechanisms influencing the EW response across the four case events, and presents whether expectations of other parties were found to influence the EW response.

Table 9. Cross-case comparison of the four case events

Case event	Underlying cause	Expectations influencing the EW response
A	Lack of information flow	Yes
B1	Lack of information flow	Yes
B2	Culture and interaction	No
C	Culture and interaction	Yes

6 Mitigating obstructions for addressing Early Warning signs in projects

The sub question answered in this chapter is “How can obstructions for addressing Early Warning signs in projects be mitigated?”. To answer this sub question, an expert meeting was organised to reflect on the findings of Chapter 5, and directions for solutions. Section 6.1 explains the approach of the expert meeting and its purpose. Section 6.2 presents an overview of obstructions and possible solutions that were reflected on during the expert meeting. The results of the expert meeting are presented in Section 6.3. Section 6.4 concludes the chapter by answering the sub question.

6.1 Approach

6.1.1 Goal and setup

The goal of the expert session is to evaluate the mechanisms and bottlenecks found in Chapter 5 and to discuss possible solutions found during the research and suggested by earlier literature to improve the response to EW signs in projects. By discussing the findings from the case study with experts from organisation and project level, an initial evaluation of recognisability, usability and feasibility took place.

The expert session was split in two parts: one attended by two experts from organisational field level, and one attended by two experts from project level. This allowed for more speaking time per person in the limited time available in their schedules. Because of availability constraints, the expert meetings were held digital.

6.1.2 Expert selection

The selection of experts was based on the following criteria:

- Experience in the field (inside and outside the construction organisation)
- Variation in roles and areas of expertise
- No earlier involved in this research

Participants attending from organisational field level:

- E1: Manager Project Control at the construction organisation (10+ years of experience)
- E2: Manager Operations and cluster manager design and engineering at the construction organisation (10+ years of experience)

Participants attending from project level:

- E3: Risk manager (10+ years of experience)
- E4: Project manager (10+ years of experience)

6.1.3 Expert meeting structure

The structure of the expert meeting in detail can be found in Appendix D.

The meeting is divided in four (connected) parts. First the researcher and participants of the meeting introduce themselves. Then, an overview of research findings is presented. After each mechanism is introduced, they are discussed by the experts. Lastly, possible solutions linked to the findings are discussed.

6.2 Mechanisms and possible solutions

Possible solutions for mechanisms found in the case study research in Chapter 5 that were presented in the expert session are mentioned in this subsection. These were either formulated as main lessons from the case events in Chapter 5, or mentioned by literature as potential solutions.

6.2.1 Lack of information flow prevents identification of Early Warning signs

The way the information flow at a project is organised seems to influence whether an EW sign can be identified.

To improve the information flow in a project, changes in the guidelines of the organisation regarding information storage and handling can be a possible solution. The current system is not organised to store EW information, as was found in Chapter 4. Especially the phase transition from tender to execution phase was found to be prone to information loss. Storing data regarding possible EW signs regularly can prevent this information from getting lost.

Increasing awareness on similar challenges faced in past projects, and extracting lessons learned from previous projects can be helpful for identifying and responding to EW signs. Setting up a lessons learned database, containing accessible EW information from past projects, was a possible solution suggested in Chapter 4. Ansoff et al. (2019) mentioned a systematic use of response strategies in projects to be helpful for keeping track of EW signs. Knowing what can be expected, and examples of how to react to those situation, could improve the identification of EW signs. Storing data during projects is important to be able to fill the database.

Nikander & Eloranta (2001) conclude that experience of personnel in a project is important to identify more EW signs. To prevent losing information during a project due to the replacement of tender personnel at the transition to the project phase, keeping more tender personnel on board can be a solution.

6.2.2 Group culture and team interaction hinder response to Early Warning signs

The impact of group culture and interaction in the project team was found to hinder the response to EW signs. To influence this effect, Williams et al. (2012) suggests to focus on creating a work environment where personnel feels safe to speak up on unpopular issues.

Personnel now seems not convinced of the benefit of recording lots of information during the project or the benefit of reacting to EW signs. Increasing pro-active behaviour of individuals towards responding to EW signs can be helpful according to Haji-Kazemi et al. (2015). From organisation level, attention can be given to possible solutions that can reduce the threshold for participating in the identification of and response to EW signs.

Findings from the case study seem to suggest that hierarchy through power places a role in how the project team reacts to EW signs, as the project manager was found to have a major influence on how a team reacts to an EW sign. As the steering committee stands further away from the project team and team culture, while they stand high in the hierarchy, they could get more involved in deciding whether to respond to an EW sign instead of mostly focussing on direct financial and timing issues in

projects. However literature mentions that other origins of power, not only hierarchy, are important as well in group interaction (Robbins et al., 2017).

Individuals not feeling responsible for further consequences of their actions was found to also reduce the attention to EW signs in projects. Team composition could be taken into account to balance risk averse and risk taking mind-sets, and thinker-doer personalities, when it is experienced that these influence the EW response.

6.2.3 Interpretations of agreements

The interpretation of agreements and expectations by a project team seems to influence how they behave in a project and react to EW signs. Discussions about the contract and discussions about Early Warning signs encountered during current actions in the project could be separated to prevent contractual discussions from taking over according to the experts from project level. Especially after the tender phase ends, grey areas in the contract should be discussed with the client to prevent wrong expectations from influencing the EW response during the rest of the project.

Taking more time to evaluate the completeness of agreements was found as lesson for improvement during the case study. This could prevent later discussions from causing time delays during construction.

6.3 Expert meeting results

6.3.1 Lack of information flow prevents identification of Early Warning signs

The experts from project level argue that an information database can be helpful against losing EW related information, and could also improve the active storing of EW information in a structural manner. The digital relatics environment currently used in projects is seen as starting point for such a system. However they also mention that a digital system cannot replace the need for individual knowledge in a project.

Using information from past projects, lessons learned, is seen as most important solution for improving the recognition of EW signs in projects by the experts. From organisation level, experts mention a similar system is being developed currently to improve lessons learned implementation in projects. Experts from project level mention the importance of knowing who were involved in previous similar projects, to enable direct contact for questions and advice. This can also improve the identification of EW signs in projects. Selecting personnel that has experience with similar projects would improve the available knowledge in a project, however that solution would not be feasible because during the initial stages of a project often the most knowledgeable team candidates are experienced to be occupied already.

To be able to use a database, data should be stored properly. Storing information during projects, for example at each quarterly report meeting, is suggested to improve the usefulness of data. At the end of a project, not all events are still remembered by personnel. The experts mention that by storing data during the project already, the lessons learned philosophy can be kept alive and fresh. Mobile applications for personnel to fill in progress or data during work-time instead of asking them to fill in forms at the end of the day could help according to the experts.

Databases should at least be efficient to search through. Ease of use is seen by all experts as important. Current open text queries in evaluation sections for example make it hard to find relevant information, this has to improve according to the experts.

A large involvement of personnel in both tender and project is seen as beneficial by the experts for not losing knowledge on project risks and possible EW signs. However, the experts recognise the risk of tunnel vision, when people are judging their own tender design decisions during the execution phase. They then cannot see a flaw in their design, or they become stubborn and refuse to see mistakes they might have made. Stubbornness is linked to project culture by the experts. Keeping key personnel while transitioning to the project phase allows for these people to be hold accountable for their earlier decisions. A balance between containing prior knowledge and introducing fresh views in a project team seems important.

The experts mention that the current practice of establishing a tender design, and financial pressure that causes risk buffers to be low are largely caused by the current market conditions, common contracts and much competition for a relatively few projects. These conditions are mentioned as restricting the type of solutions that can be implemented.

6.3.2 Group culture and team interaction hinder response to Early Warning signs

Individuals in project teams need to be able to feel safe in their environment to speak up. Most experts recognise the importance of the project manager on this environment, through his behaviour and because of his position of power. Only the project manager suggested that there are more 'key officials' at the project that might impact the project culture even more than the project manager. Informal leaders that impact the project culture in a negative way should be confronted and when needed could be replaced. Individual behaviour and the team composition are mentioned by the project manager as very impactful on team culture.

Currently, the experts from project level mention the challenges of working under the influence of a cost-driven steering committee, as the steering committee tends to not focus on other aspects, such as EW signs. The steering committee should not only focus on time and costs of a project according to the experts, but broaden the topics on which they advise the project manager on. For example, them supporting the project manager to decide how to react to an EW sign could be interesting. The response strategy model of Ansoff et al. (2019) can help to support making these decisions as well.

The experts recognise the influence that individuals can have on group culture. Regarding team composition, they experience that personnel for each project is often selected based on availability rather than experience, personality, and knowledge. Changing team composition based on personalities is seen as an interesting option.

Underestimating the impact of EW signs was mentioned as a part of project culture. A solution could be aimed at influencing individuals, to stimulate proactive behaviour. Personnel now is often not convinced of the benefit of recording lots of information during the project or the benefit of reacting to EW signs. Ease of storing information should therefore be taken into account, to make it a low-threshold activity. Increasing the awareness of personnel on how to escalate potential problems or gut feelings could stimulate proactive behaviour.

6.3.3 Interpretations of agreements

Regarding discussions based on contractual interpretations in projects, all experts advise a separate policy for contracts with a client and for contracts with subcontractors. Knowing and understanding the position of the other party and maintaining a good relation is mentioned by the experts as important in these types of discussions as well.

Discussing EW signs during the project with the client to prevent EW responses from being postponed would be possible, but can cause other problems according to the experts. In nearly every project, contractual boundaries and limits are pushed. Discussing these with a client prior finishing the project can cause (unnecessary) friction. Taking more time to evaluate an agreement can only be good for the quality according to the experts, however this is not seen of as feasible, because of time pressure during the project, but especially the risk that more problems can arise when an agreement is long, sealed off, and detailed, is mentioned.

6.4 Conclusion

The aim of this chapter was to evaluate possible solutions found during the research to reduce the effect of mechanisms that obstruct the EW response in projects. Sub question 4 can now be answered:

Q4 *How can obstructions for addressing Early Warning signs in projects be mitigated?*

Information loss at the transition from the tender phase to project phase is recognised as issue in the current response to EW signs. Improving the information flow by applying changes to the guidelines of the organisation regarding information storage and handling could be part of a solution. Striving for less personnel changes between the tender phase and project phase could also help to preserve knowledge. Here a balance between tunnel vision and fresh insights can play a role.

Experience and lessons learned are recognised as crucial for timely identifying EW signs and reacting to them. Focussing on storing more data during projects, enabling access to data from previous projects, and stimulating the use of data from previous similar projects are mentioned as potential improvements to the current situation. Human experiences and personal communication on previous situations can never be replaced by databases, and should also be supported in this process.

To improve project culture and team interaction, a safe environment should be pursued. This allows for individuals to be more open, and could stimulate the response to EW signs. Next, the steering committee should give more attention to EW signs. They could advise the project manager in evaluating EW signs. Not only the project manager was recognised as being able to influence the team interaction. Next to hierarchy, aspects such as charisma and experience can lead to influence and power in a team. Team composition should be balanced regarding individual characteristics.

Contracts and interpretations of agreements are mentioned by the experts as important, however not necessarily the completeness of the contract should be focused on. Rather, the content and consequences of the contract should be discussed more to prevent wrong assumptions and interpretations from negatively influencing the behaviour towards EW signs for too long.

7 Discussion

Scientific contributions of the research are discussed in section 7.1. In Section 7.2 the practical implications of the research for the construction sector are discussed. Section 7.3 concludes this chapter by discussing the limitations of this research.

7.1 Scientific contributions

7.1.1 Different approach and perspective

The goal of the research was to identify how the response to EW signs in construction projects is influenced. This was motivated by the limited knowledge on the use of EW signs in construction projects, and mechanisms influencing the response to EW signs. Previous research on the topic of EW signs was conducted from the perspective of clients, or focused on the interaction between client and main contractor in construction projects. This research focused on the subcontractor, and the way the subcontractor internally deals with EW signs in projects. The interaction between contractor and subcontractors was also part of this research. Case study research from this new perspective contributes to the expansion of current literature regarding the response to EW signs. In the case study, projects with mainly DB contracts were analysed from the client's perspective, where the subcontractor was responsible for both the design and execution of the projects.

To better understand how the response to EW signs is influenced, the perspective of organisational behaviour theory was applied to the field of EW signs. OB theory investigates the impact of individuals, teams, projects, and the construction organisation on human behaviour within organisations, or in the case of this research: construction projects. Analysing behaviour and dynamics in projects while recognising the four levels of organisational behaviour interaction resulted in a broader understanding of the EW phenomena in construction projects. The four levels of organisational behaviour theory seem to help improve understanding of how and why people act in projects and influence the EW response from multiple levels.

7.1.2 Comparing findings with literature

During the case study research, two main mechanisms influencing the response to EW signs were found: the influence of group culture and team interaction hindering the response to EW signs, and the lack of information flow in projects preventing the identification of EW signs. A third mechanism found, is the influence of interpretations of agreements on the EW response. Overlap with current literature, and findings that appear to be new are now discussed.

The first mechanism, group culture and team interaction hindering the response to EW signs, was also mentioned in earlier literature from a client's perspective as barriers for responding to EW signs (e.g. Haji-Kazemi, 2015; Williams et al., 2012). The inductive approach of this research enabled the aspects of group culture and team interaction causing the effect to be analysed in more detail. It seems that, mainly on team level, EW signs that are discussed, are not taken seriously. The focus of the project management and project manager on current costs and timing instead of considering the potential impact indicated by an EW sign was also found connected to this. This is also something found by previous research, as Williams et al. (2012) for example mentions "no cost/no time-effects leading to optimism bias" as barrier for responding to EW signs. Underestimating the potential

impact not reacting to an EW sign, and lacking experience to evaluate an EW sign, where found on individual level to influence the response to EW signs. These were not recognised in earlier research. This could be become of the client's perspective used in this research.

The second mechanism, the lack of information flow in projects preventing the identification of EW signs, appears to not be found by earlier research. This mechanism is mainly caused by the lack of attention to EW signs in the organisation of the information system. Information that is not stored properly, is lost during the project, especially at the phase transition of tender to execution phase. EW signs later are not recognised as personnel is unaware of where to look for EW signs. The importance of having access to enough information, and not losing information that could be used to identify EW signs in the project seems to not be found by earlier research.

The third mechanism found in the case study was the influence of interpretations of agreements on the EW response. Individual elements of this mechanism can be found in existing literature, such as trust (Williams et al., 2012), and responsibility (Wijtenburg, 2018). However the cohesion of the elements and the importance of expectations and agreements in particular seems a new insight.

A reason for finding these new reasons for not responding to EW signs in this research could be that current literature mostly focuses on often occurring EW signs, and how should be responded to EW signs in projects, rather than why EW sign are not identified in the first place. Another possibility could be that the importance of having access to enough data plays a large role in the EW response of contractors, but not from the perspective of clients.

This research suggests that causes for not responding to EW signs are part of mechanisms. The EW procedure model of Haji-Kazemi (2015) however, mentions causes for not responding to EW signs in the form of barriers and focuses on one barrier impacting a filter at a time. The case study results of this research suggest that one barrier could be part of a larger mechanism. If this is the case, then trying to mitigate one barrier at a time to improve the EW response seems to not be very effective, as the rest of the mechanism remains active.

7.2 Practical implications

The case study in this research shows how project teams react to EW signs from the perspective of the contractor. As this research seems to be the first to analyse the EW response from this perspective, it can show construction organisations a clear view of what EW signs are, the current state of responding to EW signs in projects, and the potential that can still be gained when bottlenecks would be countered. In general, the current organisation of the contractor appears to not be designed to deal with EW signs. Findings from this research can contribute to a discussion within the construction organisation on how much potential is seen in improving the EW response in projects. Such a discussion is key, as pro-active behaviour, and being open to respond to EW signs are seen as necessary to create a successful EW approach (Haji-Kazemi, 2015).

By assessing mechanisms for not responding to EW signs from the OB theory perspective, bottlenecks on multiple organisational levels were found. The new insights from this research suggest that the role of the organisation, in particular the influence of the organisation on the information flow in projects, should not be underestimated in the EW response. Not only the lack of response to EW signs, but also the lack of identifying EW signs in the project environment is

highlighted. Chapter 6 discusses possible solutions to improve the response to EW signs in projects based on the found mechanisms. Concentrating policy changes to affect the EW response by focusing on causes from all OB levels should increase their effectivity.

7.3 Limitations of the research

By conducting a qualitative case study research with a limited number of selected cases, the external validity of the research is constrained (Verschuren et al., 2010). When more projects would be researched, at the expense of more research time, it can be concluded whether findings from this research are found more often.

The data analysis method prescribed by the grounded theory methodology is influenced by the interpretation of the researcher (Bryant & Charmaz, 2007). This means that multiple researchers with the same data set can produce multiple different conclusions based on the data. This however does not directly imply that the results are less valuable or trustworthy, but should be taken into account. The analysis method however does enable inductive as well as deductive research, which is useful in an exploratory research such as this research (Verschuren et al., 2010).

In the process of data gathering, interviews were crucial for this research. Selecting more than five interviewees per case study project would have increased insights in behaviour and decisions in the project. If an interviewee now did not want to share certain information, one fifth of the gathered data of that project was impacted. Selecting more interviewees would reduce this impact. A high personnel changeover at the case study projects restricted the available interviewees. Potentially important data about the selected case study events could have been missed.

While selecting events of interest at each case study project, the project manager of that particular project was involved. Inside view bias in what events where mentioned during the initial interviews with the project managers cannot be ruled out (Yin, 2018). The project manager cannot be assumed to be neutral as he/she was involved and has interests at stake at the case study project. This bias could be reduced in future research by allowing the researcher to take more to search for projects and find out about failures and interesting events within these projects to further analyse them.

Grounded theory methodology mentions the risk of the researcher influencing the findings of the study by prior knowledge (Bryant & Charmaz, 2007). Although the researcher had little prior knowledge of the subject of EW signs and the response to EW sign in practice, biases towards certain earlier academic findings could have been unknowingly of influence on the data gathering and data analysis process. Conducting research from an academic background that focuses on systems and tables, softer behavioural aspects of responding to EW signs could be evaluated differently compared to other researchers.

Gut feelings, tacit knowledge regarding reacting to EW signs in projects, and soft EW signs being important in the early response to EW signs can make it difficult to obtain all wanted data by interviewing project personnel. Longer interviews or multiple interviews with the same person could reduce the impact of this limitation, but do not solve this issue completely. Ideally, to create the most accurate and extensive overview, the research should be conducted while the project is still going on. Due to time constraints this was not possible.

8 Conclusion and recommendations

In section 8.1, the research question and sub questions are answered. Section 8.2 presents recommendations from the research to strengthen the Early Warning response in construction projects. Section 8.3 contains suggestions for further research. Section 8.4 reflects on the research process.

8.1 Answering the research questions

The following research question was formulated to cover the research goal:

> *How is the response to Early Warning signs in construction projects influenced?*

To be able to answer this research question, the following sub questions were formulated:

SQ1 *What concepts can be related to the response to Early Warning signs in construction projects?*

SQ2 *How is the response to Early Warning signs influenced by the organisational level?*

SQ3 *What mechanisms influence the response to Early Warning signs in projects?*

SQ4 *How can obstructions for addressing Early Warning signs in projects be mitigated?*

The sub questions are now answered:

1. **What concepts can be related to the response to Early Warning signs in construction projects?**

Literature provides a wide variety of concepts related to the response to EW signs in construction projects. Different types of concepts are gathered and clustered to form a theoretical framework. A great majority of literature seems to focus on composing lists of EW signs and categories of EW signs that are encountered most in projects. Reasons for not responding to EW signs in literature are mostly based on theoretical insights and are not specified to the subject of construction projects in particular. These reason are mentioned as individual factors, current literature does not mention underlying influences between these factors.

EW response models described by literature are based around filters, which are bottlenecks in the process of identifying up to responding to an EW sign. The response to EW signs in those models takes place in a repeating pattern on project level, from first identification of the EW sign up to responding to the EW sign. Barriers are mentioned as factors that influence whether information is filtered out during this process.

Organisational behaviour (OB) theory suggests that the understanding of human behaviour in organisational settings can be improved by analysing behaviour from different levels that are part of an organisation. OB theory finds that four levels play an important role in behaviour in the construction sector: the organisational level, project level, group/team level, and individual level.

The individual level focuses on behaviour of individuals, influenced by emotions, capabilities, and motivation. Group/team level includes behaviour of individuals working together, aspects such as communication, conflict, intergroup behaviour, and cross-cultural issues play a more important role. Project level encompasses the project organisation as a whole, it is seen as a temporary organisation adapting to a dynamic and uncertain project environment. The organisational field level overarches the three other levels. The organisation is a permanent organisation from which temporary projects are steered, and teams and individuals are influenced.

Categories of EW signs and factors related to not responding to EW signs in practice from literature were explored with OB theory in mind. The following categories and concept were found in literature to play a role in the response to EW signs in construction projects:

From organisational field level, the effect of learning as organisation from previous projects, control imposed by stakeholders in the organisation, the presence of clients with unclear expectations, and the effects of politics on the organisation of projects are influencing the response to EW signs.

At project level most categories and concepts from literature can be found. Project management issues, planning issues, the coordination of design issues, uncertainty avoidance, unclear documentation, project complexity, collaboration between groups, the client-contractor collaboration, financial- and time pressure in projects, and the preparedness before starting projects are found to influence the response to EW signs.

At group level, group collaboration, communication, culture, competences of the team as a whole, and the fragmentation of information among teams were found to influence the EW response.

On individual level, behaviour, mind-set, experience, and the expertise of personnel influences how is responded to EW signs. For a project manager, individual behaviour and the management style of the manager are found to influence the response to EW signs.

The response to EW signs in construction projects is influenced by a wide variety of factors that can be structured over the four OB theory levels: individual level, group level, project level, and/or organisational field level. The interaction between factors on different levels seems important to take into account in order to understand behaviour of responding to EW signs in projects.

2. How is the response to Early Warning signs influenced by the organisational level?

By interviewing personnel from the construction organisation level and assessing documentation of the construction organisation on project approaches and guidelines, factors were gathered describing how the construction organisation influences the response to EW signs in projects. These factors are applied to the OB theory framework and sorted over the four levels of individual, group, project, and organisational field. The construction organisation influences the response to EW signs in their projects by aiming at the expertise, knowledge, and self-initiative of individual project workers to identify and act on EW signs. No concrete procedures or steps are described that are aimed at facilitating the EW response. Procedures for structuring project phases, guiding team composition, and data collection and storage exist and aim at improving project work, but are not designed to improve the EW response in some way. Regarding stimulating the response to EW signs in projects, escalation mechanisms can be used in projects to enable dismissed EW signs from still reaching further in the chain of decision making. However, general escalation documents are not

required to be formulated at new projects. This emphasises the lack of intentional influence on the EW response by the construction organisation.

3. What mechanisms influence the response to Early Warning signs in projects?

A qualitative in-depth case study was conducted to find how the response to EW signs in construction projects is influenced in practice. Comparing the outcomes and behaviour of four case events, two main underlying mechanisms appear to be found: the influence of group culture and team interaction hindering the response to EW signs, and the lack of information flow in projects preventing the identification of EW signs. A third mechanism found, is the influence of interpretations of agreements on the EW response.

The mechanism of group culture and team interaction hindering the response to EW signs seemed to play in important role in two case events, where EW signs were identified, but not responded to initially. A group culture in which EW signs are not taken seriously, where workers seem to not feel responsible for consequences of their lack of quality control, in which the collective idea is that problems will fix themselves, and in which a main focus is allocated to current timing and costs of a project rather than possible future problems for the project was found. The timing and costs oriented focus seems to be driven by the emphasis of the project manager and the steering committee on the project's budget and time schedule. Team interaction causes individuals who want to act differently and more pro-active towards EW signs to be overshadowed. Their efforts are initially not appreciated by the other project personnel. On individual level, EW signs that could be identified are overlooked because of a lack of individual experience, not being aware of what signs to look for. On the other hand, the impact of not responding to EW that are identified is unconsciously underestimated by individuals, influenced by a team culture of not wasting time on vague signs.

The mechanism of the lack of information flow in projects preventing the identification of EW signs seemed to play an important role in two other case events, where EW signs were not identified on time. EW signs were missed because information that could have been used to identify EW signs in the project was lost during the project. The organisation of the information systems in projects is not configured to store EW related information in easily, and appears to be not convenient for accessing this kind of information. Information such as possible risks that were identified during the tender phase are either not communicated, not stored in a system in the first place, or are lost at the phase transition from tender to project phase. Personnel from the tender phase active in the project phase cannot remember every detail of a design decision for example, and when this information gets lost, EW signs related to design risks can be missed. Time pressure and the pressure to come up with a competitive tender offer are mentioned as reasons that little attention is paid to EW signs during the tender phase.

A third mechanism was found, as a recurring theme in multiple case events that emerged during the data analysis process: the influence of interpretations on agreements and expectations by a project team seems to influence how was reacted to EW signs in three of the selected case events. Trusting, and/or expecting another party to finish something, or being convinced that another party is responsible for something, seems to result in a reduced attention for identifying and responding to EW signs related to associated activities. At the same time, the project team does not feel responsible to respond to EW signs related to activities that they are not responsible for themselves, even though it could be better for the project overall to pay attention to these signs.

4. How can obstructions for addressing Early Warning signs in projects be mitigated?

Obstructions caused by the mechanisms that were found in the case study research are connected to possible solutions, or directions for solutions. A discussion with experts from the construction organisation and project level on these directions for solutions resulted in an initial validation of the solutions. Remarks regarding feasibility and concerns where provided by the experts.

Possible solutions aim to reduce the impact of the found mechanisms in projects and were found during the case study research as suggestions for improvement in the future, or were suggested by literature. The directions for solutions show similarities to regular project management solutions. This could be beneficial, as this can lower the threshold of applying further developed solutions in practice.

The lack of attention for keeping track of, storing, and accessing EW related information in projects was the main obstruction found for identifying EW signs. It appears to not only be problematic for individual projects, but also the lack of learning from responding to EW signs in previous projects as an organisation is a consequence of this. A potential solution could be to change the current information management system and protocol, to allow EW related information to be stored separately, in an accessible section, to allow the information to be found during a current project as well as in future projects, looking back at the EW response at past projects. The information database further needs to withstand phase transitions in the project, mainly from the tender phase to the project phase, and should allow access to teams of multiple divisions. Next, personnel in projects should be convinced of the benefit of storing EW related information in the system, in order for the system to become a helpful tool in practice.

The loss of information in a project is also caused by a high personnel turnover in projects. Reducing personnel turnover could improve the identification of EW signs in projects. However, while having more knowledge, personnel that is involved for a longer period of time at a project may be affected by effects of tunnel vision regarding earlier made decisions. A balance between these two should be considered.

The impact of group culture and team interaction on the response to EW signs could be reduced when the importance of identifying and responding to EW signs is recognised in project teams. The observed power of the project manager in the case study shows that the project manager has a large influence on the behaviour of other project personnel. This power can be used to encourage others to identify and bring forward EW signs. Influence however does not only stem from hierarchical power. Other personnel in project teams can derive influence from being charismatic, or experienced for example. Personal characteristics and their influence on the EW response should be considered when composing project teams.

When potential EW signs are brought forward by personnel, the major source of experience of steering committee members could be used to review the signs, and to decide on a response strategy. With the current focus of the steering committee on time and costs, valuable experience regarding whether and how to act on EW signs seems underutilised.

Regarding contracts and agreements influencing the response to EW signs, more attention could be paid to the content and consequences of the contracts and agreements on a project. The content of

agreements could be discussed extensively to prevent wrong assumptions and interpretations from existing without knowing it. Not describing all responsibilities in agreements was found in the case study to affect the EW response negatively. However, the experts on the other hand mention the risk that more problems can arise when agreements are long, sealed off, and too detailed.

The main research question can now be answered:

How is the response to Early Warning signs in construction projects influenced?

The response to EW signs in construction projects seems to be influenced by two main mechanisms: (1) a lack of information flow in projects results in EW signs not being identified, and (2) team culture and team interaction obstruct a response to EW signs from being formulated. Expectations of agreements and trust in other parties in a project also seem to influence whether EW signs are given attention. Vague EW signs were found to not be responded to early on in projects, as the attention for current costs and time schedules appears to be larger than the attention for potential future issues. Concluding, to be able to utilise the response to EW signs to its full potential, and reduce the impact of potential future problems, this study presented new insights from a contractor's perspective that can be used as starting points.

8.2 Recommendations to strengthen the Early Warning response

Construction organisations can use the findings from this research to reflect on their current strategy to identify and respond to EW signs. Creating awareness among personnel, and implementing an approach that enables sharing information on EW signs between teams, within projects, and within the organisation, follow from this research as key elements.

To strengthen the EW response, EW signs should be taken into account during the whole project chain, starting at the beginning of the tender phase, until a project's completion. Developing a systematic way to keep track of EW signs with little effort, and evaluating whether a possible future strategy to respond to an EW sign should already be thought of are challenges that need to be faced.

8.3 Suggestions for further research

Suggestions for further research are partly formed based on the limitations of this research.

The mechanisms found in this research are based on data from three projects. This gives limitations with regard to the generalisation of the results. To further clarify how the found mechanisms influence the EW response, more research is needed. Further research can investigate whether these mechanisms play a role in the EW response in projects in general in the construction sector, by conducting qualitative research.

The examined projects in this study are mainly infrastructure related. Further research examining utility projects, or a differentiation between larger and smaller projects, could improve the understanding of how the EW response is influenced in other construction project types. Further research can also focus on projects in other countries, as mechanisms could be culture specific. Results from this research can also be compared with mechanisms found at other projects.

Regarding the understanding of the EW phenomenon, cross tabulation research can be conducted to explore coherences between mechanisms influencing the EW response. This would expand insights into conditions in projects that make it harder for an EW response to take place.

8.4 Reflection

This subchapter contains the reflection of the researcher on the research process.

The experience of setting-up and conducting a research on this scale was enlightening. Personal skills that are also useful outside of the scope of this research were developed, such as planning many interviews at once, conducting interviews, and running (digital) sessions attended by experts. I even got to present preliminary findings of my research to a larger audience, of around fifty people. I am very grateful for the opportunity to conduct this research at BAM Infraconsult, which gave me the ability to have these experiences.

During my study, many courses gave assignments with group work, especially during the peaks of covid infections. Individual research assignments however were not something I had a lot of experience with. Combined with the large scale of this thesis research, this made the past six months a completely new challenge.

Keeping a strong work ethic while corona measures influenced everyday life was also a quite special. Approachable supervisors, combined with access to workplaces on campus and at the BAM Infraconsult office helped me with this. Also, the ability to have conversations with other students conducting thesis research, and to discuss small details with them was helpful in the research process.

The pandemic did normalise the phenomenon of digital conversations and video meetings. For this research, digital meetings enabled the possibility to find openings in busy schedules at uncommon times to conduct interviews with people working at construction projects all over the Netherlands. However, experiencing both interviews in-person and digital, interviewing people in-person seems to result in more detailed findings, especially sensitive details of events and behaviour in projects.

The qualitative case study research method was relatively new to me, especially at this scale, which made it quite a challenge. Trying to find, read, and apply the grounded theory methodology to this research in a short time also was a new part of the challenge. Because there are so many different research methods and methodologies, it would not be feasible to use them all during one's time as a student prior to conducting the thesis research.

I have never processed such a large quantity of interview data before conducting this research. Transcribing, coding, and analysing was not possible without the help of the NVivo software I used in this process. However, as coding interview data with software was also a new to me, research improvements could be achieved. Learning more about this software, and discovering possibilities of cross-table analysis for example, made me realise that I perhaps started to soon with the coding process. If I had better researched the software possibilities, I should have been able to code in a more structured manner, enabling cross-table analysis to my coding framework.

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Appendix A: Interview protocol for exploring organisational level

A Introductie (5 min.)

1. Introductie onderzoek: Mijn afstudeeronderzoek heeft als doel om het reageren op Early Warning signs in constructieprojecten beter te begrijpen.
2. Doel van interview: Middels dit interview probeer ik me een beeld te vormen van hoe EWS binnen BAM gezien worden en hoe erop gereageerd wordt, zowel volgens standaardprocedures als de praktische invulling daarvan.
3. Omgang/verwerking interview data
    - 3.1. Uw naam wordt niet letterlijk gepubliceerd en ook uw functie en werkzaamheden zullen minder specifiek genoemd worden zodat data niet gelinkt kan worden aan u.
    - 3.2. Het interview wordt opgenomen en getranscribeerd, zal niet zomaar gedeeld worden zonder toestemming. Gaat u akkoord?
4. Vragen vooraf?

B Ervaringen geïnterviewde (5 min.)

5. Hoe lang bent u in dienst bij BAM? En daarvoor?
6. Wat is uw functie/positie en wat houden uw werkzaamheden in?

C Introductie EWS, vragen werkwijze BAM (20 min.)

7. Kent u de term Early Warning Sign? Wat betekent Early Warning volgens u?
    - 7.1. Herkent u deze betekenis in uw werk? (Kunt u voorbeelden noemen?)
    - 7.2. Besteed u hier aandacht aan? Hoe? Welke tijdfase van project?
    - 7.3. Wordt hier door BAM aandacht aan besteed? Hoe/door wie?

Betekenis EWS volgens theorie: mogelijke signalen die een indicatie zijn voor het opkomen van problemen in het project.

8. Vanuit deze betekenis: Herkent u dit soort signalen bij uw werkzaamheden en bij BAM? Krijgt u dit soort signalen door bij uw werk?

(Gebruik EW voorbeelden uit vorige vraag om volgende vragen concreter / gerichter te kunnen stellen, anders wordt design growth als voorbeeld gebruikt).

- 8.1. Hoe en wanneer in de tijdspanne van een project is er aandacht voor Early Warning, wanneer ontstaan signalen van EW? (Waar tussen de tender tot UO?) Ook in de praktijk?
- 8.2. Zijn er (harde) richtlijnen bij BAM waarin de omgang met Early Warning Signs beschreven is? Hoe wordt de huidige aanpak geborgd?
    - 8.2.1. Wordt dit benoemd in een intern kwaliteitssysteem? Worden verantwoordelijkheden voor EW duidelijk benoemd? Escalatiemodel in PMI niet verplicht, wordt dit wel vaak uitgewerkt? *(Andere verantwoordelijkheden/hiërarchie voor escalatie?)*
    - 8.2.2. Is de omgang met EWS gebaseerd op eigen ervaring/intuïtie (niet hard vastgelegd)? Of wordt dit aangeleerd?
    - 8.2.3. Hoe richt je zelf EWS in, in je eigen omgeving? Laat je dit afhangen van de grootte of complexiteit van het werk dat je doet?
    - 8.2.4. Is de huidige EWS-aanpak voldoende of effectief in uw ogen? Waar ligt dat aan? (Gebrek aan standaardisatie?)
    - 8.2.5. Ben je vooral problemen aan het oplossen of problemen aan het voorkomen in een project? (Preventief of reactief?) *(Niet stellen als al gezegd is waar definitie / nadruk EW voor hun op ligt)*
- 8.3. Tot waar in de organisatie horen EW signalen te komen? Vanuit project tot in hoofdorganisatie, of blijft dit binnen het project?
  (*Wordt PMI ook gebruikt door stuurgroepen en directie? Of alleen activiteiten die door kernteam gevolgd worden?)*

8.4. *Geen herkenning*? → Wat voor aandacht is er voor het vroegtijdig signaleren en reageren op mogelijke problemen?

8.4.1. Als er geen richtlijnen zijn, hoe dient dan te worden omgegaan met waarschuwingssignalen in projecten?

8.4.2. Waar is dit handelen op gebaseerd? (protocol, intuïtie, etc.?)

8.4.3. Hoe wordt vanuit BAM projectprocedures / protocollen aangestuurd?

8.4.4. Zijn er verantwoordelijkheden hiervoor vastgelegd?

D Vragen m.b.t. vergelijken werkwijze over verschillende projecten (5 min.)

9. Is de manier van reageren op EWS door BAM veranderd over de tijd?

9.1. Hoe reflecteer je binnen BAM bij afgesloten projecten op ervaringen van wat er bij deze projecten goed/minder goed ging (in termen van organisatiestructuur, projectaanpak, technische keuzes, etc.)? Vanuit jouw functie of bij andere functies? (*lerend vermogen organisatie?*)

9.2. Worden richtlijnen aangepast aan bevindingen uit de afgesloten projecten? (zoals feedback naar PMI omgeving om te leren van oude projecten?)

9.2.1. Wie doet dit? Hoe wordt dit gedaan?

E Hoe ervaart u de omgang met EWS in de praktijk? (theorie filters) (15 min.)

De volgende vragen gaan over hoe aspecten van de EWS filters door BAM benoemd worden in hun aanpak van EWS.

10. Hoe merkt u dat in een project wordt aangestuurd op het verzamelen en evalueren van EWS bij projecten? [Surveillance filter]

10.1. Zou dat beter kunnen?

11. Als er in het project een EW gesignaleerd wordt (bijv. scope growth) wat doe je daar dan mee? [Observer mentality filter]

11.1. Hoe stuur je dit signaal door? Wanneer/hoe benoem je dit?

11.2. Heb je een vaste strategie om te bepalen welke informatie je wel/niet doorgeeft? (Ofwel omhoog, ofwel omlaag?) (Wat blijft er uiteindelijk over van je signaal?)

12. Hoe lang is de weg omhoog naar de besluitvormer? Hoe beslist de ontvanger van het signaal hogerop wat er met de informatie gebeurt? [Decision maker mentality filters]

13. O.b.v. wat voor informatie beslist iemand die actie kan ondernemen of er daadwerkelijk actie wordt ondernomen (vast format, alleen harde cijfers)? [Political/power filter]

13.1. Beslissing door iemand bovenin de projectorganisatie of vanuit BAM zelf?

13.2. Gebeurt dit tijdig of eigenlijk te traag?

F Afsluiting (10 min.)

14. Heeft u nog vragen of toevoegingen? Suggesties voor documenten die ik gemist heb tijdens dit interview?

15. Is er genoeg aandacht voor onderwerpen zoals EWS binnen de organisatie? Waar is meer aandacht voor nodig? Mening over het onderwerp, overbodig of nuttig?

16. Zou u mij kunnen doorverwijzen naar een collega die ik op dit onderwerp verder kan bevragen voor mijn onderzoek?

Appendix B: Interview protocol for the case study

A Introductie (5 min.)

1) Introductie onderzoek
   a) Ik ben met mijn afstudeeronderzoek bezig bij BAM Infraconsult. Mijn afstudeeronderzoek heeft als doel om het reageren op onverwachte problemen in constructieprojecten beter te begrijpen.
2) Doel van interview
   a) Middels dit interview probeer ik me een beeld te vormen van hoe binnen projecten omgegaan wordt met onverwachte, ongewilde of ongeplande gebeurtenissen (afwijkingen, problemen), wat er gedaan wordt, wanneer in een project, en hoe dat in zijn werk gaat.
   De inhoud van dit gesprek wordt niet gedeeld of letterlijk gebruikt in mijn onderzoek. Ik heb echter gebeurtenissen uit de praktijk nodig als aanknopingspunt om dieper te kunnen begrijpen hoe het reactiemechanisme in een project echt werkt. Praktijk nodig om vragen te stellen aan meerdere personen hoe dit ervaren wordt. Ik stel vragen over het project, maar ik ben geïnteresseerd in hoe samengewerkt is en wordt in een specifieke situatie waarbij onverwachte gebeurtenissen aan het licht komen.
3) Omgang/verwerking interview data
   a) Uw naam wordt niet letterlijk gepubliceerd en ook uw functie en werkzaamheden zullen minder specifiek genoemd worden zodat data niet gelinkt kan worden aan u.
   b) Het interview wordt opgenomen en getranscribeerd, zal niet zomaar gedeeld worden zonder toestemming. Gaat u akkoord?
4) Vragen vooraf?

B Introductie / inleiding geïnterviewde (5 min.)

5) Hoe lang bent u in dienst bij BAM? En daarvoor?

6) Wil je wat vertellen over je achtergrond (opleiding, ervaring)?

7) Wat is uw functie binnen het project en uw werkzaamheden?

C Introductie EWS, vragen werkwijze BAM (35 min.)

8) Ik ben geïnteresseerd in situaties waarbij onverwachte zaken aan het licht komen in een project. En hoe hiermee omgegaan wordt.
   Een ongewenste/onverwachte gebeurtenis met impact op het project die ik tegenkwam was: …
   Kun je vertellen over deze onverwachte/ongeplande/ongewilde gebeurtenis in het project? In het design management proces?

9) Hoe en wanneer kwam dit aan het licht? Weet je waar de melding vandaan kwam? Wat is erover gecommuniceerd?

10) Hoe is [het probleem] opgevallen? Wanneer werd er aangeslagen? Zou er ergens eerder kennis geweest van kunnen zijn hiervan? Hoe is er gehandeld en waarom op die manier? Wie besteedt er in een project aandacht aan?

11) Wat verhinderde of bemoeilijkte het proces dat iets gedaan werd met dit gegeven/vermoeden? Waar liep je vast? Welk gevoel heb je erbij? Krijg je dit door van anderen? Filters herkenbaar?

12) Wat is uiteindelijk gedaan om iets aan deze situatie te veranderen? Hoe is signaal doorgestuurd? Via/naar wie?

13) Hoe worden beslissingen genomen bij zo'n [probleem]?

14) Hoe heeft dit fout kunnen gaan? Waarom heeft dit kunnen gebeuren? Gevoelens erbij?

15) Is er een procedure vastgelegd bij dit project om dit soort gebeurtenissen te voorkomen of om vermoedens te melden? Zou deze gevolgd zijn? Zou die algemeen bekend zijn?

16) Welke richting, afdeling of persoon zou me dichter bij de bron van zo'n melding kunnen brengen? Waar/welk persoon zou als eerste een gevoel kunnen hebben gehad dat iets zo zou lopen?

17) Wat staat hiervan in documentatie beschreven?

D Vragen m.b.t. vergelijken werkwijze over verschillende projecten (10 min.)

18) Is de manier van reageren op EWS anders dan bij andere projecten?

    a) Wat doe je bij afgesloten projecten met ervaringen van wat er bij deze projecten goed/minder goed ging (in termen van organisatiestructuur, projectaanpak, technische keuzes, etc.)?

    b) Zijn richtlijnen aangepast aan bevindingen uit de afgesloten projecten? (zoals feedback naar PMI omgeving om te leren van oude projecten?)

F Afsluiting (5 min.)

19) Heeft u nog vragen of toevoegingen? Suggesties voor documenten die ik gemist heb tijdens dit interview?

20) Zou u mij kunnen doorverwijzen naar een collega die dichter bij de onverwachte/ongewilde gebeurtenis staat in het project? Dat ik die kan bevragen voor mijn onderzoek?

Appendix C: Expanded codebook of interview transcripts

Codes	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5
1 : Level 1 Individual	0	1	1	9	0	0	4	0	3	1	0	2	2	0	3
2 : Individual behaviour	0	0	1	6	0	0	3	0	0	1	0	2	0	0	0
3 : Lack of weak signal mind-set and sensitivity	0	0	1	4	0	0	1	0	0	0	0	0	0	0	0
4 : Sign of weak signal mind-set	0	0	0	2	0	0	1	0	0	1	0	0	0	0	0
5 : Lack of experience	0	0	0	2	0	0	0	0	1	0	0	0	0	0	1
6 : Lack of expertise	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7 : Manager characteristics	0	1	0	1	0	0	1	0	2	0	0	0	2	0	3
8 : Negative for EW behaviour	0	0	0	0	0	0	0	0	2	0	0	0	0	0	3
9 : Positive for EW behaviour	0	1	0	1	0	0	1	0	0	0	0	0	2	0	0
10 : Level 2 Team/group	4	9	6	14	6	9	6	3	9	6	10	8	11	3	16
11 : Communication	0	2	1	1	1	0	0	0	0	1	1	0	0	0	2
12 : Fragmentation of information	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
13 : Positive for EW response	0	1	1	0	1	0	0	0	0	1	0	0	0	0	2
14 : Error found by project team	0	0	0	0	0	0	1	1	1	2	0	0	0	0	1
15 : Error in design calculation not noticed	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0
16 : Group collaboration	0	1	0	2	0	2	2	1	0	1	4	3	7	2	3
17 : Negative for EW response	0	1	0	0	0	2	0	0	0	1	2	0	2	0	1
18 : Positive for EW response	0	0	0	2	0	0	1	0	0	0	0	2	0	1	1
19 : Group culture	0	1	3	3	2	3	1	1	7	1	0	1	1	0	5
20 : Starting construction prior to approval or agreement of	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0
21 : Lack of commitment as team	0	1	0	0	0	1	0	0	2	0	0	0	0	0	0
22 : Optimism bias	0	0	0	0	0	1	0	1	1	0	0	0	0	0	3
23 : Reluctant or afraid to report issues and thoughts	0	0	2	1	0	0	0	0	1	0	0	1	0	0	0
24 : Sticking to their own idea or assumption	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
25 : Missing competence as project team	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
26 : Not feeling responsible	0	0	0	0	0	1	2	0	1	1	3	1	0	0	2
27 : Interacting with hard vs. soft data	1	3	0	3	1	0	0	0	0	0	1	2	1	0	0
28 : Project management issues	0	1	0	0	0	0	0	0	0	0	0	1	1	0	2
29 : Planning issues	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 : Project control and reporting issues	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0
31 : Subcontractor influences EW behaviour	2	1	2	4	3	2	0	0	0	0	1	0	2	1	2
32 : Negative	2	1	2	2	1	2	0	0	0	0	0	0	0	0	0
33 : Blind trust in subcontractor	1	0	1	2	0	2	0	0	0	0	0	0	0	0	0
34 : Irritation because of mistake in subcontractor's desig	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0
35 : Subcontractor did not share issues or thoughts	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
36 : Positive	0	0	0	0	0	0	0	0	0	0	1	0	2	1	2
37 : Error was found by subcontractor	0	0	0	0	0	0	0	0	0	0	1	0	2	1	2
38 : Error found by subcontractor using standard protocol	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
39 : Level 3 Project	4	10	6	26	3	8	9	7	8	4	15	8	12	8	12
40 : Collaboration between groups	0	1	0	0	0	0	0	0	0	0	1	1	0	2	2
41 : Importance of stakeholder management at construction	0	0	0	0	0	0	0	0	0	0	1	1	0	1	2
42 : Complexity of techniques	3	1	3	6	0	0	0	0	0	0	1	0	1	0	1
43 : Subcontractor is unable to perform complex technique	1	0	2	4	0	0	0	0	0	0	0	0	0	0	0
44 : Uncertainty underground	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
45 : Financial pressure	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0
46 : Influence of client	0	0	0	0	0	1	3	1	0	1	6	2	2	4	5
47 : Lack of expertise client	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1
48 : Client does not inform EW related information	0	0	0	0	0	0	0	0	0	0	2	1	0	2	0
49 : Client was informed by contrractor	0	0	0	0	0	0	2	1	0	1	1	1	0	0	0
50 : Delegated client acts on behalf of client	0	0	0	0	0	0	0	0	0	0	2	0	1	2	2
51 : Client mistrusts contractor regarding claiming extra cos	0	0	0	0	0	0	0	0	0	0	1	0	1	0	2
52 : Preparedness before starting project	0	2	0	5	1	2	1	2	3	3	0	1	1	1	1
53 : Negative influence of transition from tender to project e	0	0	0	4	1	1	1	1	3	2	0	1	1	1	1
54 : Problem was not recognised during tender	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
55 : Project team composition	0	2	2	3	0	1	1	2	1	0	0	1	2	0	0
56 : Project structure	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0
57 : Special / unusual contract type	0	0	0	0	0	0	0	0	0	0	1	3	2	1	1
58 : Disagreement between parties on contract interpretatic	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0
59 : Steering committee	0	0	1	2	0	1	1	2	0	0	1	0	0	0	0
60 : Time pressure	1	2	0	2	1	1	2	0	1	0	3	0	1	0	1
61 : Time pressure during tender	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0
62 : Uncertainty avoidance	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
63 : Unclear documentation	0	1	0	6	1	2	1	0	3	0	2	0	2	0	1
64 : Level 4 Organisational field	1	1	1	2	2	1	1	3	3	5	0	1	3	1	1
65 : Client with unclear expectations and role	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66 : Control imposed by stakeholders	0	1	0	0	0	0	0	1	0	0	0	1	2	1	1
67 : Effects of politics on projects	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
68 : Lessons learned	1	0	1	2	2	1	1	2	2	2	0	0	1	0	0
69 : Best practice applied from previous project	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
70 : Lack of learning from previous projects	1	0	1	2	2	1	1	1	1	2	0	0	1	0	0
71 : High change over of personnel during project	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0
72 : Learning as individual not as organization	1	0	1	2	1	0	0	0	0	0	0	0	0	1	0
73 : No trust in good project result by people in organization	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0

Appendix D: Structure of the expert meeting

Agenda and structure used for each expert meeting:

1) Entry of experts in the meeting (5 minutes)
2) Explanation of goal of the expert meeting (1 minute)
3) Experts introduce themselves (5 minutes)

[Spreadsheet presentation starts]

4) Introduction to the research (5 minutes)
5) Influence of project culture and project manager's behaviour (12 minutes)
    a) Explanation
    b) Discussion of the mechanism
    c) Discussion of solution spaces
6) Influence of contracts and agreements (12 minutes)
    a) Explanation
    b) Discussion of the mechanism
    c) Discussion of solution spaces
7) Influence of experience and lessons learned (12 minutes)
    a) Explanation
    b) Discussion of the mechanism
    c) Discussion of solution spaces
8) Influence of preparedness before starting, and information loss at transition tender to project (12 minutes)
    a) Explanation
    b) Discussion of the mechanism
    c) Discussion of solution spaces
9) Conclusion, overview of results of the meeting, open discussion (10 minutes)

[End of expert meeting]