Uncertainty and Ground Conditions
A Risk Management Approach

Martin Th. van Staveren
Uncertainty and Ground Conditions
To Annelies, only she knows why.
Uncertainty and Ground Conditions: A Risk Management Approach

Martin van Staveren
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The open GeoQ framework for managing ground-related risk, as presented in this book, emerged after the start of the third millennium. Writing this book has only been possible with the indispensable support of many pioneering individuals and teams over the last years, in The Netherlands and abroad. These professionals have both technical and non-technical backgrounds and work at many different firms, government agencies, universities and institutions. They dared to try-out parts of the GeoQ concept in their projects and together we learned a lot from it. These experiments resulted in the case studies in this book. I want to thank all of these professionals, for their opinions, suggestions and feedback on the GeoQ risk management approach.

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PART ONE

The context of ground risk management in the construction industry
1 Introduction

A new type of ground risk management book

How can we live without construction? It fulfils many of our fundamental needs and has existed since the earliest development of mankind. Incorporating engineering and maintenance activities, construction, provides us with houses, schools, hospitals, industrial plants and infrastructure. We are all affected by these structures, hour after hour, day after day, year after year.

There is no construction without ground. Any kind of construction needs a foundation. Any construction, whether very small or extremely large, has some form of connection with the inherently uncertain ground. Our ability to cope with this uncertainty will make a difference between our foundation settlements or not, between excess groundwater in our basements or not, or even whether our structures collapse during an earthquake or not.

Until now, the ground has always been a major driver of risk in many construction projects all over the world. This is reflected in the relatively high failure costs and often small profit margins in the construction industry. Many projects are completed at a higher cost than estimated, as well as much later than scheduled. This causes serious additional expenditure for clients, reduced profitability or even losses for contractors and a lot of irritation for the public.

For many years, risk management has added value in many sectors and industries, such as the financial sector, the chemical industry and the offshore industry. In construction, however, risk management has not been entirely incorporated and exploited, in spite of the industry’s inherent uncertainties and high risks. The application of well-structured risk management during all project stages, from feasibility through to construction and maintenance, needs to be started or extended to many more projects. This situation is particularly apparent in ground-related engineering and construction activities.

A serious obstruction to the introduction and application of risk management is the people factor. Together, we are that people factor. Typical human attitudes and behaviour, driven by unawareness and fear, often prevent us from considering
risk in a timely and effective way. As a result, we will miss opportunities to optimize projects and benefits for our organizations, our clients and our societies as a whole remain hidden and untouched.

The combination of these four interrelated aspects, construction, ground, risk management and the people factor, provides an opportunity for a new type of risk management book. Is there a need for it? Yes, I think there certainly is, in spite of a number of related books published over recent years. Examples are those written by Edwards and Bowen (2005), Weatherhead et al. (2005), Smith (2003, 1998), Boothroyd and Emmet (1996), Godfrey (1996), Edwards (1995), Flanagan and Norman (1993) and Thompson and Perry (1992). All these books cover risk management in the construction industry, but do not focus on ground risk management. The number of available books that cover ground-related risk management in particular is limited. Although works by Clayton (2001), Hatem (1998) and Skipp (1993) do focus on ground risk management, they pay little attention to the people factor. None of these books combines the four interrelated factors dealt with in this book.

**Objectives and target readerships**

The main objective of this book is to contribute to the application of cost-effective ground risk management. It considers ground conditions in their widest definition and includes all types of ground, groundwater, ground-related pollution, and all forms of man-made structure. The latter refers to buried structures, such as pipelines, piles or archaeological remains.

In today’s increasingly global market we must differentiate or die, according to Trout and Rivkin (2000) in their guideline on how to survive killer-competition. Ground-related innovations in engineering and construction are urgently required to gain competitive advantage. This book’s secondary objective is therefore that ground risk management should act as a sort of airbag against the inherent business risks of innovations. A similar risk management approach has been used in other industries. For instance, the Risk Diagnosing Method (RDM) proposed by Keizer, Halman and Song (2002) has been successfully applied in the consumer electronics and food industries.

GeoQ, where Q stands for quality, will become the vehicle to meet our objectives. It is an easy-to-use and flexible framework for ground risk management during the entire life cycle of all types of construction projects. It is independent of the type of ground conditions expected and can reveal many hidden and ground-related opportunities, such as cost savings, tighter schedules, improved project quality and increased profitability for a lot of stakeholders. Anyone can make GeoQ fit-for-purpose, to meet the specific requirements of any small or large construction project, anywhere in the world.
Given these objectives, the main target readership will include civil engineering and construction professionals involved in ground-related issues in some way. They may be working with contractors, engineering firms and clients, studying for BSc, MSc and MBA degrees or teaching and performing research at universities and institutes. Here we recognize construction managers, project planners, project designers, geotechnical engineers, soil engineers, rock engineers, engineering geologists, ground-related scientists, graduate and postgraduate students.

I hope to inspire and motivate this anticipated variety of readers, who will all encounter their ground risks in some form throughout their careers. If many of you start to participate in the worldwide adoption of structured ground risk management, we will be able to make a difference in the rapidly changing construction industry.

State-of-the-art of ground risk management

The state-of-the-art of ground risk management, as presented in this book, is a mixture of theory and practice. It is derived from a variety of engineering, business administration and human sciences and includes many aspects of ground engineering and construction, some physics, statistics and geology, as well as several fundamentals of psychology, sociology, and even some philosophy. According to a modern risk management approach, as proposed by Edwards and Bowen (2005) for instance, risk is considered to form both an obstruction and an opportunity for project success.

Empirical developments are major drivers for innovation, particularly for ground-related engineering and construction. I, therefore, do not intend to present a new scientific risk management theory, but will present a structured and risk-prone way of thinking and doing.

GeoQ ground risk management is a form of process innovation that typically emerged by trial and error. It has been applied in a wide range of projects, including tunnels, (rail)roads and even a waste disposal site, resulting in its present state-of-the-art. Common scientific approaches, such as objectivity and the proof of principle by experiment, are used within the limitations of the available experience. I have included abundant references from a variety of disciplines to support and criticize my opinions about and experience of ground risk management. Colleagues from all over the world suggested many of these, others I approached by purpose or just came across.

The GeoQ framework should not be seen as having arrived its final state of development. It has been introduced only recently and there will be ample opportunity for further improvement. Many of the GeoQ supporting practices that are presented, such as scenario analysis, risk identification and classification methods, ground investigations, and the observational method with monitoring,
are not new but are readily available to deliver GeoQ support. Some may demand further development to increase their cost-effectiveness and ease for daily use in ground risk management.

The first part of this book pays particular attention to thinking and reflection, while the second part is mainly concerned with learning by doing. This combination will not be able to prevent each and every project crisis from time to time. Risk management is by no means a panacea capable of preventing all risks in ground engineering and construction activities. If we can merely reduce the probability of such risks occurring, as well as their effects, then the objectives of this book will have been achieved.

The book’s structure

The structure of this book is designed to help first-time users, who are not yet familiar with risk management, as well as experienced professionals using the book as a reference guide for applied ground risk management.

According to John Naisbitt (1984): ‘What happens is that whenever new technology is introduced in society, there must be a counterbalancing human response – that is high touch – or the technology is rejected.’ GeoQ ground risk management, with its technological tools, should be appraised as a form of new technology. Experience teaches the importance of giving ample attention to professional attitudes and behaviour. If not, risk management becomes little more than a tick-box exercise and a waste of our precious time and money. This explains the high tech and high touch approach in this book: to provide fertile ground for a wide acceptance and application of ground risk management. Figure 1.1 shows the book’s structure, together with the corresponding chapters.
Chapters 1, 2 and 3 serve as the foundation slab and bear the three pillars of GeoQ ground risk management and its future: people, processes and expertise. Following the introduction in Chapter 1, Chapter 2 presents a number of challenges and opportunities for global construction. It serves as an appetiser for Chapter 3, which brings us from uncertainty, via risk, risk management and the ground, to the concept of GeoQ.

Chapters 4 to 6 focus on the high touch or human factor, the combination of people and risk. These chapters highlight the need for risk awareness and the inherent differences in people’s perception of risk. Chapter 4 identifies certain characteristics of individual risk perceptions, as well as how individuals can contribute to effective risk management. Chapter 5 explores the interaction of individuals in teams, including aspects such as team culture and risk communication. The way in which teams may contribute to ground risk management is also discussed. Chapter 6 describes how clients and society perceive the risk caused by construction. We can use their insights to guarantee more effective communication about (ground) risk with these stakeholders.

Chapters 7 to 13 explore the high-tech side of ground risk management, in particular the technical-organizational or process aspect. These chapters present the application of the tried-and-tested GeoQ method in six generic project phases, to provide us and our teams, clients and society with high quality construction products. To guarantee maximum benefits, six subsequent risk management steps must be taken in each phase. Chapter 7 introduces this GeoQ process. Chapters 8 through to Chapter 13 present its application during the feasibility, pre-design, design, contracting, construction, and operation and maintenance phases. Each chapter begins with several ground risk mitigation measures and tools, followed by a variety of case studies, where GeoQ steps and tools will add value to the project. These are intended to help understand the many types of projects where GeoQ can be applied. Which GeoQ tool should we apply to which situation? There is no generic answer, all that can be said is: it depends. Concise summaries are presented at the end of each chapter. Finally, Chapter 14 highlights briefly some of the main opinions and conclusions of this book, followed by some type of outlook to a prosperous construction industry, as perceived from a ground risk management perspective.

The third pillar below the GeoQ concept shown in Figure 1.1 is expertise of ground engineering and construction. Many textbooks and papers are available about ground engineering, soil mechanics, rock mechanics, groundwater engineering, environmental engineering and engineering geology and provide plentiful information. This book provides numerous examples of the benefits of sound, up-to-date expertise, as well as experience, as these remain ultimately necessary for responsible and cost-effective ground risk management.

In addition to figures and tables, numerous text boxes are included in the chapters. These should be seen as a side step for reflection on the issues presented,
whose purpose is to raise awareness and provide fresh insights rather than give
definite answers. Readers are invited to jump from chapter to chapter, based on
their own interests, experiences and needs. Introductions and summaries in each
chapter provide a quick overview of their content. Before starting to apply the
GeoQ process using the guidelines and experiences described in Chapters 7 to 13,
I recommend that you first read Chapters 4 to 6. After all, it is people like you
and me who are responsible for construction and its associated ground risks.
Introduction

The magnitude of construction is enormous and a number of major challenges affect its current state. This chapter explores the ever increasing complexity, the relatively underdeveloped integrity and the substantial failure costs associated with construction activities. Ground conditions play a major role in these aspects.

Is there an ongoing crisis in our industry? Perhaps there is, but the good news is that new solutions and opportunities continue to emerge. In recent years, a number of countries have initiated ambitious change programmes for the construction industry. In this chapter we will meet some of these initiatives, as they may help us cope effectively with the challenges we face.

This chapter introduces the concept of systems thinking, a potential key to unlock possibilities for the required industry transformation. It stipulates fertile ground for the concept of risk management. The last part of the chapter highlights the need for a critical mass of change-driven professionals. These individuals will be essential for implementing ground-related risk management, as presented in this book, in day-to-day engineering and construction practices. The summary presents the key issues of this chapter.

The magnitude of the world’s construction industry

The global construction industry is huge, and will continue to grow substantially in size. Based on a report by Global Insight, Sleight (2005a) predicts an increase in construction spending from 3500 billion US dollars in 2003, to 4800 billion US dollars in 2008 and 6200 billion US dollars in 2013. We should note that a billion is here