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# Geotechnical Risk Management in Dutch Public Infrastructure Projects

Cees BRANDSEN and Paul M.C.B.M. COOLS
*Rijkswaterstaat, Ministry of Infrastructure and the Environment, The Netherlands*

**Abstract.** In the Netherlands more and more attention is paid on reducing geotechnical failures in civil engineering projects. This paper focusses on describing the contractual measures and procedures Rijkswaterstaat as a client has developed and implemented in recent years for this purpose. The principles of Geotechnical Risk Management are leading.

**Keywords.** Geo Risk Management, Infrastructure, Contracts

## 1. Introduction

The Netherlands, which literally means "low lands", is a European country lying at the North Sea in a delta of the rivers Rhine, Meuse and Scheldt. Without our levees, dams and storm surge barriers about half of the country would be covered with water. Approximately 17 million people live together on an area of some 40.000 km2, making the Netherlands one of the most densely populated countries in the world.

Within this context, flood protection against the sea and rivers and reliable mobility by highways and railways are key elements of our infrastructure. Each year about 16 billion euros are spent to construct and maintain this infrastructure, of which more than 6 billion euros from our Ministry.

This paper will focus mainly on the activities and the experiences of Rijkswaterstaat regarding managing the geotechnical risks of their infrastructure.

**Figure 1.** Movable barrier "Maeslantkering"

## 2. Reducing Geotechnical Failures

In the past decade a number of incidents took place during and after construction of civil engineering projects, of which the causes all were soil related. The consequences of these failures were sometimes severe. They caused delays in construction time, cost increases of the project and additional costs for society.

About half of the failure costs in the construction industry are expected to be directly or indirectly soil related, due to unexpected and unfavourable ground conditions (Van Staveren, 2006). Moreover the good reputation was damaged not only of the contractor, the designer and the principal but also of the civil engineering community as a whole.

In 2009 Rijkswaterstaat took the initiative to invite all relevant stakeholders in the civil engineering sector to discuss this problem. All parties recognized the sense of urgency, agreed that is was a mutual problem and showed their willingness "in euros and hours" to contribute to a solution. This was the start of the Geo-Impuls programme.

## 3. The Geo-Impuls Programme

The goal of this programme is "reducing geotechnical failure in projects by half in 2015". Some 35 organizations, clients, contractors,

consultants and knowledge institutes combined forces and created a budget of 6,5 million euros.

Three major geotechnical risks were identified: 1) large settlements or collapses, 2) unforeseen soil conditions and 3) loss of public support. Over 150 persons from the sector started working in twelve working groups on separate solutions to reduce these top risks (Cools, 2011).

During the execution of the programme a number of tools were developed by the working groups and successfully applied in projects. The number of published geotechnical incidents of failures dropped already by more than 50% in four years time. (Cools et al., 2014).

## 4. Geotechnical Risk Management (GeoRM)

During all phases of a project the risks need to be identified and classified and remediation measures have to be taken to manage these risks. In the nineties a specific method for project risk management was developed in the Netherlands by Rijkswaterstaat, ProRail, City of Rotterdam, Delft University and Twynstra Gudde, called RISMAN (Van Well-Stam et al, 2004). This method now is widely used by clients, contractors and consultants. At Rijkswaterstaat, for the design and construction of all projects this risk based approach is applied and they are all managed risk driven.

With the Geo-Impuls programme the Dutch construction sector created more awareness and urgency on the importance of specifically the geotechnical risks and of ways to control them better by Geotechnical Risk Management (GeoRM). In the United Kingdom, the Institution of Civil Engineers paid attention to GeoRM already before (Clayton, 2001) as well as in the Netherlands by GeoDelft, now Deltares (Van Staveren, 2006).

From the beginning of the Geo-Impuls programme it was decided nót to develop a new method, but to support and elaborate on the existing RISMAN approach. Within GeoRM, eight Geo-principles were identified and developed and translated into specific actions to be considered (Van Staveren, 2013).

## 5. Procurement and Geotechnical Risks

The procurement of civil engineering works is one of the core businesses for clients in the public sector.

To control effectively all risks involved during the construction and maintenance of these works, both client ánd the contractor first of all need to have and use a general system of quality assurance in their organizations.

During the tendering phase the project risks have to be identified, or information made available in the specific contract documents of the work.

At one of the yearly meetings of the Geo-Impuls programme with all the sponsors, the Director General of Rijkswaterstaat has announced that also GeoRM will become an integral part of our quality assurance and will be required during tendering. Also other clients like ProRail and the four big municipalities are considering similar steps.

**Figure 2.** Movable barrier “Oosterscheldekering”

## 6. Quality Assurance

At Rijkswaterstaat we require that a contractor operates with a certified quality management system. This is the fundamental idea behind our so-called System Based Contract Management. The contractor himself is responsible for the quality of his products. He defines the processes,

controls the risks, warns in time for problems, takes measures and evaluates regularly. To verify the required quality we plan control checks and reviews during the project, which mainly are focused on the top risks, including geotechnical risks.

Rijkswaterstaat itself also works with a quality management system, which is called the Guideline Construction and Maintenance. It describes by a number of procedures the way we work in projects. About a year ago a GeoRM procedure was included, which requests the attention of the project team for geotechnical risks in every project phase.

**Figure 3.** "Van Brienenoord" bridge in Rotterdam

## 7. Contract Documents

When consultants are involved during the planning of projects at Rijkswaterstaat, they have to work within the framework of our Guideline Construction and Maintenance and the GeoRM procedure.

During the realization of a work however, we are not allowed to prescribe and demand the use of GeoRM by contractors as a method. The working method is a choice the contractor has to make himself.

However there are other contractual methods to ensure that the contractor will address the geotechnical risks properly.

### *7.1. Geotechnical Criteria for Selecting and Granting*

Firstly, Rijkswaterstaat uses several criteria to select applicants and to grant a contract, based on price, quality and performance, like e.g. reductions on project costs, more sustainability or less public hindrance. Also the use of a risk management plan may be one of the criteria regarding quality. In this plan specific geotechnical sub-criteria can be included, like e.g. the vision of an applicant on the implementation of GeoRM in the realization of the project, its integration with project risk management and ways to ensure its quality.

### *7.2. Geotechnical Requirements in the Contract*

A second way to ensure that contractors will control geotechnical risks properly is simply demand specific geotechnical requirements in the contract. Examples of these requirements may be a maximum of residual settlements or the settlements of adjacent buildings or presenting a monitoring plan to control the hindrance due to vibrations.

## 8. Incentives

It is not only in the interest of the clients, but also of the contractors and consultants to implement GeoRM in their organizations and projects. During the Geo-Impuls programme all parties have recognized this and are making important steps in this direction (Van Staveren et al, 2013a, 2013b).

The two contractual measures that Rijkswaterstaat mentioned are mainly additional incentives to show and convince the client that they are in control regarding GeoRM. In this way applicants can prevent that they might be excluded for tendering, because they do not satisfy the geotechnical selection criteria or will not be able to win the bid, as the scores for the geotechnical criteria are too low.

If the geotechnical requirements in the contract are not met after granting the contract, this could lead to withholding of payments as contract conditions are not satisfied.

## 9. Additional Geo Risk Management Tools

During the Geo-Impuls Programme a number of tools have been developed to improve the management of geotechnical risks by clients, contractors and consultants.

### *9.1. Geo Risk Scan*

The Geo Risk Scan aims to monitor and control the quality of GeoRM application in a certain phase of the project. During the scan, the quality of the process and of the content are assessed and scored, which may lead to recommendations (Bles et al, 2009).

An easy to apply protocol now is available, which describes the procedure and method of a Geo Risk Scan, during one day only. In this way, contractors, consultants and clients are able to scan their own projects, but also other projects in which they are not directly involved.

**Figure 4.** Closure dam "Afsluitdijk" 1932

### *9.2. Guideline on Risk-Based Site Investigation*

During tendering there always is a big pressure to collect timely all the relevant soil properties of the project site.

The guideline on risk-based site investigations presents how to derive the investigation scope which is needed in a project, given the risk profile and degree of risk tolerance acceptance within the project.

The role of both client and contractor is indicated for each project phase, while taking into account the various types of contract. This approach has been elaborated for a large number of different types of structures, by including separate descriptions for each type.

### *9.3. Database of Geotechnical Risk Checklists*

Geotechnical risk checklists enable the geo-engineers to identify and assess the risks in their projects. They are related to the existing RISMAN-method for project risk management.

There are specific checklists for a building pit, pile foundation, waste depot, pumping station, dike and road. For each type, all possible negative events and causes are described during each project phase and within different disciplines of geo engineering.

### *9.4. Brochure on the Awareness of Geotechnical Risks for Non-Geotechnical Decision Makers*

The brochure is aiming to reach clients who have in their organisation no geotechnical background or knowledge. It points out to clients, but also to project developers, contractors and architects of possible risks in the subsoil of their projects. Specific attention is given to adjacent buildings, special structures, time and location, dikes, groundwater, soil characteristics and unexpected obstacles.

### *9.5. Geotechnical Project Sieve*

At Rijkswaterstaat geotechnical expertise is limited and scarce and the number of projects is substantial (over 300 each year). It is impossible to manage the geotechnical risks of all these projects in the same detail. With the risk driven approach in mind, as described in chapter 4, the geo-engineers developed a tool called "Geotechnical Project Sieve" to handle this problem.

When a new project is initiated a quickscan is performed which will indicate the geotechnical risk profile. The project is scored on four criteria: 1) the type of project: on, with or in the soil 2) the location: soil properties and phreatic level 3) adjacent buildings 4) the "rush" to finish the project.

Depending on the outcome, a project will get more or less attention of the geo-engineers and of the reviewers, as described in chapter 6.

**Figure 5.** Inflatable rubber weir "Ramspol"

## 10. Risk Allocation and Sharing

In general a client is inclined to allocate the project risks and will ask parties to solve them. This looks like a sound approach but may lead to parties that either will or will not include provisions or cost to avoid the allocated risks. During tendering, applicants differ in to which extend they will calculate these risks and add a premium to the costs.

However, it is very likely that some but not all risks will be materialized during construction and so the client may be confronted with a partner that did not address properly the geotechnical risks, than the client will always pay too much.

### *10.1. Risk Allocation*

A general rule in risk management says that risks best can be controlled by that party who has the best capabilities and qualifications to manage them. Acquiring permits for example is more routine for a client, while ensuring the stability of a structure is daily work for a contractor. In this way specific risks may be allocated to one specific party, contractor or client.

### *10.2. Risk Sharing*

Sometimes there are risks in a major project of which no party has a hold on. Also in case of a project with innovative items, there may be risks involved which we cannot foresee beforehand, the so-called "black swans".

An interesting and promising solution for these problems may be to generate a risk fund, filled by client and contractor, to cover unforeseen risks that materialize. At the end of the project the remainder of this risk fund is split between both parties.

This risk fund may be generated by deliberately not applying a remediation measure which prevents a foreseen risk. The costs saved are donated in the risk fund and the relevant parameters are monitored during construction by means of the Observational Method..

In the past decade Rijkswaterstaat has acquired positive experience with this type of risk sharing in projects, by using a so-called 'alliance contract'.

## 11. Geotechnical Risk Allocation

In many projects it is not always obvious who will be responsible for any of the geotechnical risk.

Since 2000, the principles of the Geotechnical Baseline Report (GBR), developed in the USA, have been used in construction projects in the Netherlands, called 'Risk Allocation – Geo- Engineering' (RV-G).

A Working Group of the Geo-Impuls programme has evaluated the application of RV-G in seven projects by interviewing their clients and contractors. Everybody involved agrees that the method clearly provides the ownership of the geotechnical risks before the project starts.

Especially for the client, the comparison of the bids during bidding is easier, because the geotechnical risk profiles of all bidders are similar.


**Figure 6.** Construction pit.

## 12. Recommendations

In the Netherlands and within Rijkswaterstaat specifically we have developed several tools and are gaining more and more experience regarding the management of geotechnical risks. With this knowledge we have come to a number of recommendations.

### *12.1. Geo Risk Management*

It is in the interest of the client and the construction industry that there will not be a competition with respect to geotechnical risks during tendering.

This realization brought us to the decision of application and implementation of the principles of Geo Risk Management in our projects to prevent this "pitfall".

Moreover, with GeoRM there remains a "level playing field" between bidders and how they want to address the geotechnical risks.

The client should not impose its experiences with GeoRM on the contractor by giving a preferred solution, but the contractor himself should come up with his ideas how to solve the identified risks.

### *12.2. Foreseen Risks*

The client may or must require from the contractor that he will take notice of all foreseen risks and will manage them properly.

The contractor has a responsibility to inform the client the way the contractor manages these risks and the way he monitors them during construction.

### *12.3. Transparency Versus Competition*

Transparency between the client and contractor, built on a clear contract and with a clear understanding that geotechnical risks are always around the corner will lead to more partnership and confidence between the parties that the project is properly managed.

Risk sharing, as mentioned in paragraph 10.2, in alliance contracts implies transparency between the client and applicants during the so-called "dialogue phase".

However, this requires for contractors to overcome their reluctance to share information which might make the difference during tendering.

Clients on the other hand should sympathize with these difficulties for the contractors and ask all bidders to show what is included in the final offer with respect to risk allocation both in terms of money and measures.

All risks should be transparent in the bid, but not all mitigating measures can be shared in a tender phase with all parties, that would destroy the essence of competition. But this leaves both client and contractor with the question have I been clear enough, an essence of risk management.

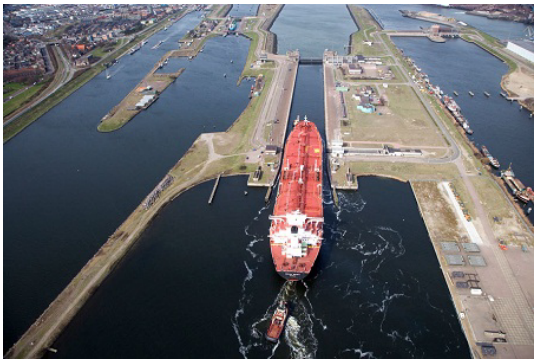

**Figure 7.** Sea lock at Ijmuiden

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