RISK MANAGEMENT OF EARTHWORKS USING GEOQ

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ABSTRACT

Large budget overruns within infrastructure projects seem to become common practise over the last decades. In the Netherlands and also world-wide these overruns of public funds have become less and less acceptable. Within the construction industry awareness grows that failure costs have to be decreased significantly. Studies to assess failure costs conclude with figures of 4 to 9 billion Euro annually for a small country as the Netherlands only. Approximately 50% of these failure costs are directly or indirectly related to sub-surface conditions.
The question was raised whether one should speak of a crises of the underground or of a managed risk. In answer to this question, GeoDelft has developed a general approach named GeoQ to deal with sub-surface risks and thus control total project costs.

Very often, cost overruns during the construction of some large infrastructure project can be back traced to little or no attention for subsurface related risks in the early plan or design phase of the project. To enable a fair discussion on subsurface related risks in every phase of the project, the GeoQ approach strives to bring transparency in the many implicit decisions taken in a project.
The first cornerstone of the GeoQ approach is a cyclic, risk based approach of design, and construction in every phase of a project. The second cornerstone is to mobilise all relevant information and knowledge to enable continuity of information between the various project phases. This will lead to an improvement of the total quality of the project and a related strong decrease of unexpected cost.

Stimulated by a new, experimental contractual relation between client and contractor, construction of the Sliedrecht-Gorinchem section of the Betuweroute freight railway demonstrates that awareness of subsurface risk enables value engineering resulting in significant optimisations. In this project the GeoQ approach, supported with some state-of-the-art design and monitoring tools, formed the basis for savings up to 10 % of the total project costs (e.g. 20 million Euro). This success was realised within a very tight contractual time frame, in an area known for its extremely soft soil conditions.

KEYWORDS

GEOQ / PROCESS INNOVATION / RISK MANAGEMENT / FAILURE COSTS / QUALITY / GEOTECHNICS

1. INTRODUCTION

Large budget overruns within infrastructure projects seem to become common practise over the last decades. In the Netherlands and also world-wide these overruns of public funds have become less and less acceptable. Within the construction industry awareness grows that failure costs have to be decreased significantly. Studies to assess failure costs conclude with figures of 4 to 9 billion Euro annually for a small country as the Netherlands only. Approximately 50% of these failure costs are directly or indirectly related to sub-surface conditions. The question was raised whether one should speak of a crisis of the underground or of a managed risk.

1.1 Crisis or manageable risk?

When talking of a crisis, the first question to be asked is the dimensions of it. For an impression some numbers are presented below to illustrate the crisis:

- the costs of failure amount to 25 % of the total building budgets (source: SBR Dutch Foundation of Building Research);
- 20 % of the turnover of foundation companies in the Netherlands (approximately 100 MEuro) is labelled as costs of failure (source: NVAF Dutch Society of Foundation Constructors;
- the loss out of efficiency from the entire engineering and construction process amount to 20 % of the total turnover, approximately 9 billion Euro (source: TNO Bouw);
- 30 % of the total turnover in the engineering and construction process can be amounted to loss out of efficiency (source: UK, Lathan Report).

Established overruns for some recently carried out large scale infrastructure project in the Netherlands are stated in the table below.

projectname	overrun	
	projectduration	projectcosts
Inflatable weir Ramspol	+ 80 %	unknown
Tramtunnel The Hague	+100 %	+ 90 %
Stormsurge barrier Nieuwe Waterweg	+ 50 %	+ 40 %
Betuweroute freight railway	unknown	+ 65 %
Splay railway Amsterdam – Utrecht	+ 65 %	+ 25 %

Source: RIB AKI, 2000

At an estimate 50 % of these exceeding costs are directly or indirectly soil-related. Analysis of the estimate and of the plans, executed for highways in the province Zuid-Holland, it appeared that exceedings are mainly caused by:

- the diversion of underground cables and pipelines;
- the sanitation of polluted soillocations;
- underestimation of the geotechnical conditions;
- the execution of archaeological ground research;

- the to be taken mitigating measurements.

To make these soil-related risks transparent at an early stage of the project, in order that these risks can be properly managed in the following stages, demonstrably leads to a better control of the total project costs.

1.2 National Developments

Next to the above mentioned aspects also other developments can be mentioned who stress the importance of the early insight in project risks and the weighing of them, and to put in structurally experiences to ground the assessment. Developments like modern forms of contracting and partnering (think of the UK Rethinking Construction) must lead to a reduction of exceeding costs of failing constructions and must also lead to economic optimisation of design and construction.
Opposite from the above mentioned aspects construction projects get larger scaled, new infrastructure has to be bundled with existing infrastructure, the total construction time gets shorter and the technical and functional demands of the construction get more strict.

2. THE GEOQ PROCESS

2.1 Introduction of GeoQ, underground for risk control

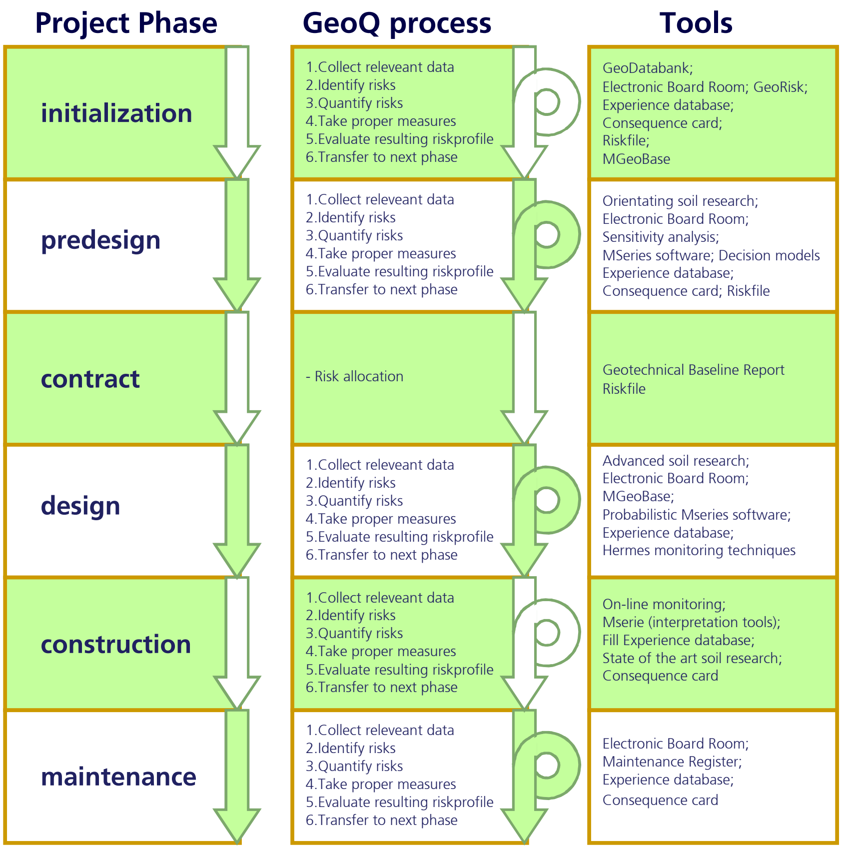
Passing through the process of realising a construction project is one of a constant assessment of risks. An assessment mostly grounded on knowledge and experience of the process or from other projects. The underground is a in many construction projects, which can make or break the project. Early and proper attention for the underground in all of its aspects (geotechnical aspects, foundation matters, environmental aspects, archaeological aspects, cables, pipelines, etc.) is essential to implement the above mentioned developments successfully.

For this reason GeoDelft has developed the so called GeoQ concept. GeoQ ensures the quality (Q) of the soil-related aspects in the construction industry by means of a risk driven approach. GeoQ takes care of the availability of the proper underground information during each phase of the construction project, given the risk profile which is agreed between the two parties. The GeoQ ‘toolbox’ is forms by Delft GeoSystems. This is a web-based software workaround, not only with geotechnical calculation models, but also with experience databases and tools for underground risk controlling, like the Geotechnical Baseline Report (GBR) and the Electronic Board Room (EBR).

2.2 Cyclic risk management

For infrastructure projects GeoQ translates into an approach with identical steps in the process in each phase, but with a different effort. For example in the initialisation phase the construction alternatives are mainly considered from aspects related to spatial fitting. With the aid of existing historic soildata, specific knowledge of the soil conditions in the region and experience (experience databases) a significant tribute can be given at this stage. Think for example at the financial consequences of a marked-out road on soft soil in stead of on more sandy layers. These so called consequence areas can be visualised with the aid of

consequence cards. Areas predominantly covered with soft soil layers can be made visible at a glance.
In the following project stages again and again the first step is to start with a risk analyses based on the existing and known data, which amount and detail level grows every stage. Risks on the field of road design, design of construction works, construction phasing, cables and pipelines and influence on the direct surroundings can be sufficiently ensured. With the aid of for example soil field research (from surveying research in the pre-design stage to state-of-the-art research in the design and construction phase) the design and construction is made more secure. Also can be chosen for a conscious acceptance of a recognised risk in the design phase, for example to optimise the total construction time during the construction phase. On this risk (for example the risk of instability of earthworks) can be anticipated during the construction phase by setting up a geotechnical monitoring program (coupled with fallback options when unexpected failing occurs). On this way budget overruns can be minimised en economic optimisation can be realised. Also a more accurate fixation of the project budget in the early phases of the project is made possible in this way.



In the next chapter you can see an example of GeoQ in practice. Here is shown that risk management of earthworks pays out. For the Betuweroute, the Sliedrecht-Gorinchem section, built on a very soft soil underground, active risk management in the design and construction stage led to an optimised design and a building time within the requirements for lower costs than estimated originally.

3. CASE BETUWEROUTE SLIEDRECHT-GORINCHEM

The Betuweroute is a double-track freight railway and the first railway in the Netherlands that is designed exclusively for freight transport. The 160 km kilometres of freight track will ensure that cargo arriving at the port of Rotterdam is transported quickly and safely to the European hinterland.
The Sliedrecht-Gorinchem section of the Betuweroute is the most difficult part of the new railway track. It runs parallel to sensitive existing infrastructure, available construction time is short and critical for the total project and last but not least, local soil conditions are very poor. Situated in the western part of the Netherlands, a typically Dutch polder landscape and its delicate hydrological systems had to be crossed.

3.1 Alliance

The overall high risk profile of the Sliedrecht-Gorinchem section of Betuweroute, especially regarding several geotechnical issues, formed the starting point for the formation of "Waardse Alliantie", an alliance between ProRail Project organisation Betuweroute (client) and HBSC (a combination of four Dutch and Belgium contractors: Heijmans, Boskalis, Structon and CFE). Together they took on the challenge to re-design and build this Betuweroute section within a tight time schedule and within a fixed budget. Both parties agreed to share cost of identified risks including unexpected soil conditions and damage to existing infrastructure. On the other hand, the alliance was challenged to optimise the available design as cost reductions would also be shared among the parties involved. Originally, ten years of maintenance was included in the contract to guarantee a qualitatively sufficient design.

3.2 Geotechnical risk management

GeoDelft, involved as strategic adviser for the geotechnical aspects in the project, was challenged by the contractors within the alliance to go beyond traditional design standards. Because of the poor geotechnical situation the traditionally used geotechnical calculation models weren't by far sufficient to design a realistic and economic construction. Covering all uncertainties with a rigid type of design would cost many millions of Euro extra in advance, whereas new risks would be introduced as consequence of such a (virtually) conservative design.

Therefore the re-designing phase started with the following steps:

- grounded on the known information the main project risks were identified and classified;
- the consequences of these main project risks were maximally ensured by putting up management measures for them (including fallback options);
- the risks and measurements were periodically evaluated and there was a check for possible new risks.

The main goals of the Alliance were to:

- optimise the design, based on traditional design standards, tot reduce the project budget;
- optimise on the construction time with the aid of risk management during the design and construction phase;
- push back the chance of failure during construction to save costs of failure and to improve the quality of the project.

The mentioned goals for the Alliance combined with the known geotechnical risks resulted in the choice of a intense monitoring program during construction time to meet the requirements. Soil displacements (vertically and horizontally) were monitored periodically on more than a thousand locations for control and predictions. Water pressures in the underground were monitored on some three hundred locations with a minimum of twice a day to control the stability of embankments and to predict the construction time.

The following paragraphs show two examples of the geotechnical risk management as applied on the Betuweroute.

3.3 Control of embankment stability and post construction settlement

A major risk of the alliance was the uncertainty whether the post-construction settlement specifications could be met using a traditional sand fill with wick drains to accelerate settlements. Settlement predictions with various theoretical models showed an unacceptably large variation in results and indicated unacceptable long constructions times.
Specific for the soils in the Sliedrecht-Gorinchem is the combination of a high compressibility with a very low permeability of the soil. The related extreme low coefficient of consolidation implies an expected low construction rate (small heightening steps, long periods between each heightening step) and large creep settlement.
The risk analyses and awareness within the team that predictions based on geotechnical calculations are far less accurate than often suggested, led in many different locations to the choice for construction based on the observational method.
Construction was planned is such a way that experience gained in the beginning of the project could be used in a later stage. Just after the start of the alliance, two test-embankments were constructed to calibrate soil strength and deformation parameters. The 22 km of embankment was split in to sections with an equal risk profile. For example stability of an embankment during construction is not such a hot item in the middle of the polder area, whereas instabilities should be avoided in the sections where Betuweroute runs parallel with an existing railway or motorway.
After optimisation of the construction speed, further statistical analysis of the soil parameters, online monitoring and the introduction new settlement calculation methods created confidence that the criteria for post construction settlement could be reached [Molendijk, Van, Dykstra, 2003].

3.4 Embankments parallel to existing railway and motorway

The second example of such a situation is the 9 km of embankment section where Betuweroute runs parallel to the existing railway Dordrecht-Geldermalsen or the A15/E31 Motorway [Molendijk & Peters, 2003]. Originally, to minimise disturbance of the existing infrastructure, a sheet pile wall was planned in between the two embankments. Deformation of the existing track induced by settlement of Betuweroute is prevented in this way and both client, owner of the existing track and contractor found this a “safe” solution.
However, a risk analysis at the start of the alliance showed something different. Little was known about the condition of the existing embankment. Experience with the installation sheet piles in the existing track learned that compaction damage and the related extra maintenance needed, could be significant. Furthermore, withdrawal of the sheet piles in a later stage might result in the formation of wells under the existing track as the hydraulic head of the sand

layers to were the sheet piles would have been placed, rises to approximately 0.5 m above the surface. Of course, such formation of wells can be prevented but this would significantly increase costs.
The approach chosen, based on the observational method, resulted in a more favourable risk profile because of an earlier start of construction (and related less post construction settlements), less hindrance for the traffic and less maintenance to track and pavement (compared with the original design based on installation and withdraw of sheet piles). Last but not least, a saving of 4 million Euro was realised for this part of the project.

3.4 Conclusions

Although the Sliedrecht-Gorinchem section of Betuweroute will be finished on the 12th November 2003, yet it can be concluded safely that the challenge of the Waardse Alliance to meet all technical requirements within the contractual time frame and within the original budget of 1999 has become reality (a reduction of 5 to 10 % of the total project costs e.g. 10 to 20 million Euro is expected).

The GeoQ process methodology, which has created the systematic framework for dealing with the geotechnical risks in the Sliedrecht-Gorinchem section of Betuweroute, has indisputable played and important role in the success of the Waardse Alliance.

Thanks to the success of the Waardse Alliance, the GeoQ process methodology is now adopted in several new project. Project managers become more and more aware of the importance of a sound risk analysis on sub surface related issues, already starting in the very early planning phase of a project.

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