Geo Risk Scan – a successful geo management tool

Geo Risk Scan – un outil du management géotechnique avec succès

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ABSTRACT

Ground conditions appear a major source of cost and time overruns in infrastructure projects, which recent Dutch research confirms. As an answer to these cost and time overruns, the application of well-structured and ground-related risk management has rapidly evolved in recent years. The Geo Risk Scan proves to be an effective tool for quickly providing information about the degree and the quality of geotechnical risk management in infrastructure projects. This paper describes the Geo Risk Scan, as well as its application within five projects. The evaluation of the five projects resulted in six main lessons. These lessons may help project owners, engineers, and contractors to manage their construction projects.

RÉSUMÉ

Les conditions du sol se trouvent d'être une source importante des excès du coût et temps dans les projets infrastructurels, confirmé par des recherches en Pays-Bas récemment. L'application du management des risques, bien structuré et en rapport avec sol, a évolué rapidement dans les années dernières, en réponse à ces excès du coût et temps. Le 'Geo Risk Scan' se montre d'être un outil effectif pour obtenir rapidement l'information du management des risques géotechniques, concernant le volume et la qualité, dans les projets infrastructurelles. Ce manuscrit décrit le 'Geo Risk Scan' et son application dans cinq projets. L'évaluation de ces cinq projets a abouti à six leçons importantes. Ces leçons peuvent aider les propriétaires du projet, les ingénieurs et les constructeurs, de manager leur projets du construction.

Keywords : infrastructure projects, geotechnical risk management, lessons learned

1 INTRODUCTION

1.1 *Successful and unsuccessful projects*

What makes the difference between a successful and an unsuccessful construction project? Is it its completion well within budget, time, and its requirements?

It cannot be the project size and complexity, because there are successful and unsuccessful small and large project. Moreover, there are simple and complex projects. It is also not depending on the project location, because every country seems to have its successful and problematic projects. It is even not because of ground conditions. We all know examples of successful projects that are completed in very difficult ground conditions. There must be another reason. Perhaps, it is the way the project management team is able to manage the inherent presence of risk, during all phases of realizing the project.

1.2 *Risk management as an answer to failure costs*

Several studies indicate that failure costs in the construction industry are typically 10 to 30 percent of the total construction costs (Avendano Castillo et al., 2008). This seems to be a worldwide phenomenon. There is also abundant evidence that unexpected and unfavourable ground conditions have a serious stake in these failure costs (Van Staveren, 2006). In the Netherlands, Rijkswaterstaat, the Centre for Public Works of the Dutch Ministry of Public Works and Water Management, is initiator and owner of all federal infrastructure projects. Therefore, Rijkswaterstaat decided to pay particular attention to the management of geotechnical risk within their projects.

1.3 *Geotechnical risk management*

The development and application of geotechnical risk management gets more attention in recent years. More and more, it is considered an effective and efficient way of work process for controlling all types of ground-related risk. For instance Deltares, formerly known as GeoDelft, developed the GeoQ-method (Van Staveren, 2006). The GeoQ approach is in fact an in-depth application of the RISMAN project risk management method. GeoQ focuses on controlling ground-related risks. The method is based on six generally accepted risk management steps:

1. Determination of project objectives and data collection;
2. Risk identification;
3. Risk classification;
4. Risk remediation;
5. Risk evaluation;
6. Transfer of risk information to the next project phase.

These risk management steps should be explicitly taken in all phases of a construction project. Ideally, the geotechnical risk management process starts in the feasibility phase and is continued during the (pre)design phase, the contracting phase, the construction phase and the operation and maintenance phase. Obviously for being effective and efficient, the geotechnical risk management should be aligned with more general project risk management approaches. Because of the similarity of risk management steps, this should be no problem.

Proceedings of the 17th International Conference on Soil Mechanics and Geotechnical Engineering
M. Hamza et al. (Eds.)

doi:10.3233/978-1-60750-031-5-2657

The main differentiating feature of geotechnical risk management, when compared to generic project risk management is its specific attention to geotechnical risks and its remediation. Therefore, geotechnical risk management uses conventional risk management approaches, such as qualitative risk assessments, as well as specific geotechnical approaches. The latter includes for example risk-driven site investigations and monitoring programmes.

2 SRUCTURE OF A GEO RISK SCAN

2.1 *Introduction and objectives*

For gaining insight in the degree and quality of geotechnical risk management in projects, Rijkswaterstaat asked Deltares to perform a Geo Risk Scan on five selected projects out of the top 20 largest Dutch infrastructure projects. The main objectives were gaining insight in the type and characteristics of ground-related risks, the possible consequences when these risks would occur, and the degree to which risk remediation measures were taken within the projects. Moreover, the results of the Geo Risk Scan would generate a quality judgement about the degree of geotechnical risk management.

In order to achieve these objectives, the Geo Risk Scan aims to scan quickly both *process* and *content* of the geotechnical risk management within a project. The execution of a well-structured risk management process, by taking the presented six risk management steps, is considered as the main boundary condition for generating effective and efficient geotechnical risk management.

If necessary, recommendations for the owner's project organisations have been provided, for improving project performance and reducing the probability of occurrence of ground-related failure costs.

2.2 *Structure of a Geo Risk Scan*

The basis of the Geo Risk Scan is the GeoQ approach mentioned above. Using this approach, the Geo Risk Scan was executed by focussing on aspects such as distinguishing between the geotechnical process and the geotechnical content. Furthermore, within the specific context of a project, the scan was executed from a generic analysis towards a more detailed one. Any scan started with a qualitative analysis, while quantitative analyses would only be performed when considered necessary, based on the qualitative analysis. The structure resulted in the following four stages for the Geo Risk Scan:

Stage 1: Geo Quick Scan, a qualitative process test;
Stage 2: Geo Check, a qualitative content and product test;
Stage 3: Geo Risk Analysis, a quantitative content analysis;
Stage 4: Geo Risk Management, as a routine work process;

The first two stages form the Geo Risk Scan; the latter two stages can be completed within a project, depending in the results of the first two stages. The last stage about implementing geotechnical risk management within a (project) organization is beyond the scope of this paper and for instance elaborated in Van Staveren (2009).

3 EXECUTION OF A GEO RISK SCAN

3.1 *Execution and results of a Geo Quick Scan*

In order to be able to perform this stage, first one has to gain insight in the project objectives and context. Therefore, an interview is planned with the project management team. It is important to have at least an interview with the technical project manager, who is normally the person being responsible for the technical part of a project. For larger projects, it can be of good help to interview the risk manager (when present within the project), project leaders of specific elements of the project, and the contract manager.

The interview is based on a standardized questionnaire and deals mainly with the GeoQ approach. Examples of questions are:

- Is the GeoQ approach recognizable in the scanned project?
- Are all six GeoQ steps executed, in an explicit way?

It is important to know whether a risk management step is performed explicitly, by following a plan, or just as some sort of unaware coincidence. In general, when a step is performed only implicitly, it is not guaranteed that in next project phases the same risk management steps are applied. This could cause negative consequences. Further insight is gained by asking for the products available from these steps and the knowledge and tools that have been used in the project to assist in the elaboration of the steps.

Next, the interview results and the gathered information are analyzed and evaluated. Scores are based on Table 1 and the accompanying legend. Moreover, the application of the six main lessons learned (next chapter in this paper) is checked. Besides the score, recommendations are provided for improving the ground-related risk management process.

Table 1. Scoring the Geo Quick Scan.

GeoQ steps	Degree of explicit execution	Degree of complete execution
1. Setting objectives and data collection		
2. Risk identification		
3. Risk classification		
4. Risk remediation		
5. Risk evaluation		
6. Transfer of risk information		

For each GeoQ step, 1 to 5 points are scored. These scores are based on the degree of explicit execution of each step and the degree of complete execution. If the GeoQ step is not performed at all, the score is 1. If a GeoQ step is explicitly and completely performed, the score is 5. Summing the score for the six GeoQ steps provides the total score. Total scores below 20 are classified very insufficient. Total scores above 28 are excellent. In between the classifications are insufficient (20 to 21 points), moderate (22 to 23 points), sufficient (24 to 25 points), and good (26 to 27 points).

3.2 *Execution and results of a Geo Check*

The work in the Geo Check phase is focussing on the points of attention resulting from the Geo Quick Scan. The Geo Check deals particularly with the content or quality of the ground related risk management within the project of concern. Geotechnical analyses and calculations are checked qualitatively, by making use of experienced geotechnical engineers. New calculations are not performed in this stage. The primary objective is checking the geotechnical work already performed by the owner. For example, the following questions should be answered during the Geo Check:

- Are all relevant geotechnical risks been identified?
- Are calculations been performed for the identified risks?
- Are the appropriate geotechnical models applied?
- Are calculated results according to expectations?

Despite the experience of geotechnical experts, it is of major importance to ensure that all foreseeable geotechnical risks are indeed identified. Therefore, using standardized checklists is very useful. These checklists have been developed for building pits, roads, and dikes, for quickly gaining insight in the completeness of the identified ground-related risks. These checklists proved to be of good assistance in all performed Geo Checks.

All risks in the checklists are classified as geotechnical risks, geohydrological risks, geo-ecological risks, risks related to objects or obstacles in the ground, risks related to contract requirements or construction risks. All risks are described in terms of causes and consequences. The consequences are by definition unwanted events.

By using this structure of the checklists, it is possible to use them on different scales. If the project is still in the feasibility phase, risk identification can only be done on the scale of unwanted events. When more detail is required, one can work from causes to sub-causes and estimate the risks accordingly.

When a Geo Check is performed, the owner gains insight in the presence of unacceptable ground-related project risks, the degree to which risk remediation measures are defined and executed, and which unacceptable risks remain yet untouched. These insight generate recommendations for improving the in-depth quality of ground related risk management. Besides these recommendations, a risk table is presented, which includes a description of the risk causes, the probability of occurrence and effects, the resulting risk, as well as the risk after taking the risk remediation measures. Such risk tables proved to be a more practical way of displaying the risks of a project than conventional two-dimensional plots with probabilities and effects, without loosing insight. Finally, the Geo Check is evaluated by giving a 'report mark' on a scale from 1 to 10, based on expert judgement.

3.3 *Evaluation of the Geo Quick Scan and Geo Check*

This section concerns an overall evaluation of the Geo Quick Scan an Geo Check. After execution of the Geo Quick Scan (process) and the Geo Check (content), overviews of the degree of ground-related risk management of each individual project are available. Rijkswaterstaat asked for a project portfolio of all scanned projects, for comparing the results of the individual projects.

Generally, risk management content or quality is considered of more importance than risk management process. After all, if the ground-related risk management results of a project are good, the project objectives are likely to be not adversely affected. Therefore, projects with bad scores for the Geo Quick Scan still can get a moderate or even good overall score on ground-related risk management. Nevertheless, these projects should keep focus on improving the process of ground-related risk management, for controlling possible future ground-related risks. Maybe, it was only a coincidence that the content-part of ground-related risk management of the project had good results!

3.4 *Execution and results of a Geo Risk Analysis*

The aim of the Geo Risk Analysis stage is to improve projects ground related risk management, either with focus on process, or with focus on content by performing extensive and if necessary quantitative analyses. Analyses are executed on unacceptable risks, as identified in the Geo Check. Moreover, recommendations of both the Geo Quick Scan and the Geo Check are elaborated. If necessary, advanced risk management tools can be used, as well as geotechnical calculations. Examples are the use of an Electronic Board Room for brainstorm expert sessions, contractual risk allocation by the Geotechnical Baseline Report (GBR), geotechnical model experiments, field monitoring, and so on. This makes it possible to analyse and quantify any remaining unacceptable risks in order to select and execute proper measures. At the end of the Geo Risk Analysis stage, the optimal risk assessment strategy should be selected for each unacceptable risks. Possibilities are avoiding the risk, reducing risk probability and or consequences, and risk transfer towards a third party. The latter measure is related to insurance and is commonly only possible for risks with a low probability that can not be controlled.

4 LESSONS LEARNED

The evaluation of the five scanned projects resulted in six main lessons, each complemented with one or more recommendations. These lessons and supporting recommendations are presented and briefly described in this section.

4.1 *Lesson 1 – Clear risk management positioning*

Lesson 1 concerns the positioning of ground-related risk management within the project and involved two recommendations.

Recommendation 1: *Ground-related risk management should be an integral part of project risk management, but with explicit status.*

In all of the five scanned projects, ground-related risks were an integral part of the total project risk management. From a project management point of view, this seems a good strategy, because more aspects than only ground-related risks are of importance for a project.

However, ground related risks need special attention, having specialists dealing with them and executing specific remediation measures. Most remarkable is that ground-related risks have mainly consequences during the construction and maintenance of the project. Consequently, these risks are often not given the attention they need, or thought about as solvable, during the design phase. In each project it is therefore recommended that in early project phases, geotechnical experts determine whether or not unacceptable ground-related risks may occur in later phases of the project. Therefore, ground related risks need an explicit status in the total project risk management. In two of the five scanned projects this approach was used with good results.

Recommendation 2: *All specific ground-related risks should be part of the project's overall risk register.*

All ground-related risks should not only have an explicit status, they should also be part of the project risk register. Often, only imprecise ground-related risks are part of the project risk register. For example, phrases like "soil investigation is insufficient for making a good design". Such fuzzy descriptions make explicit risk management difficult and probably even impossible. It is unclear which measures have to be taken and what the anticipated effects are. Therefore, it is recommended that the ground-related risk register is part of the overall project risk register.

4.2 *Lesson 2 – Clear risk management responsibility*

Lesson 2 highlights the importance that any identified ground-related risk needs one or more owners. Otherwise, the risk will not get the required attention for adequate remediation.

Recommendation 1: *Appoint a coordinator who is responsible for the ground-related risk management process within the project.*

Scanning the five projects showed the importance of somebody in the project acting as a coordinator of all ground-related

issues. The quality of the project improved largely by such a coordinator. It is not necessary that this person also is responsible for the ground-related risks. The technical manager of a large infrastructural project is usually too busy to give ground-related risks the proper attention. The mentioned coordinator should therefore assist the technical manager.

Recommendation 2: *All ground-related risk should be allocated contractually to one or more of the parties within a project.*

Because of the inherent ground-related uncertainty it is very important to contractually arrange the responsibilities for unwanted events caused by differing soil conditions. One could simply divide all risks to one or the other party, but often partial risk allocation is preferred. For instance the principles and practices of the geotechnical baseline report (GBR) are recommended (Essex, 2007). The main principle is to allocate any risk to the party involved that is best able to manage the risk. Sometimes sharing a risk is preferred, as both parties are (un)able the manage the risk by their own.

Recommendation 3: *Ground-related risks completely allocated to the contractor needs still being evaluated by the owner.*

In integrated contracts, many risks are transferred from the owner to the contractor. However, the owner still bears consequences when the risks occur. This is especially the case for immaterial consequences, like loss of reputation, safety or political risks. The owner's project management team can use monitoring and other quality checks. These checks should not only be process checks, but should also include in depth analyses of content.

4.3 *Lesson 3 – Clear risk communication*

Lesson 3 stresses the importance of transparent risk communication between all parties involved in the project, as early in the project as feasible.

Recommendation 1: *Link the functional and technical level of the project explicitly to each other.*

All five scanned projects used integrated contracts, where the contractor also had to design or even to finance and maintenance. This implies that the owner has to pay much attention to the functional description of project specifications. Technical experts have difficulties in translating their recommendations to this functional level. On the other hand, project managers have difficulties in translating the technical requirements of the experts to functional requirements. Only one out of the five projects excelled in this link, between the owner's project management team and the ground-related technical experts. This precious link was formed by one person, who could 'speak both languages'. This is recommended for every project. Obviously, any project specification should be checked on feasibility, from a geotechnical point of view. For instance, no settlements at all is usually a very expensive requirement.

Recommendation 2: *The risk file of the owner should be known by the contractor and vice versa.*

The owner of the five scanned projects had a dilemma about sharing their risk file with the contractor. Many different concepts of sharing this information (or not) were encountered. One might think it is desirable to show the contractor all identified (ground-related) risks and vice versa. By doing so, owners however feel like attracting responsibility to themselves, because the information given to the contractor may be incorrect. Another rationale is that with innovative design and build type of contracts, one might be push the contractor in some direction, when exchanging risk information. It is recommended to consider balancing these options.

4.4 *Lesson 4 – A ground-related risk register*

As part of the overall project risk register there should be a correct, complete, and up-to-date ground-related risk register that incorporates all identified ground related risks. Obviously, the risk cause(s), risk effect(s), risk classification, risk responsibility and risk remediation measures should be clear within the register. Any risk need to be described in a clear language.

4.5 *Lesson 5 – R isk-driven site investigations*

From a well-implemented ground-related risk management process, the required in-situ ground investigation and supporting laboratory research can be identified. Six basic steps can be used (van Staveren, 2006), in order to be sure that the required information is gathered. Flexible site investigations, performed in several phases that correspond with the project phases are recommended, because this approach will match the risk tolerance within the project with the required number and quality of ground-related information.

4.6 *Lesson 6 – Risk-driven field monitoring*

Finally, field monitoring is an excellent tool for controlling ground-related risk during the construction and operation phases of projects. Obviously, these programmes need to be defined according to the risk profile of the project. With integrated contracts, often monitoring is coordinated by the contractor. However, the owner should always check the results of the applied monitoring for the key-risks of the project. Monitoring should not only be checked according to the process, but regular in-depth analyses of content should also be applied.

5 CONCLUSIONS

Unexpected ground conditions appear a major source of cost and time overruns in infrastructure projects, which is confirmed by recent Dutch research. The presented Geo Risk Scan proved to be an effective tool for quickly providing information about the degree and the quality of ground-related risk management in infrastructure projects. The six main lessons and supporting recommendations, which are derived from using the Geo Risk Scan in five major Dutch projects, seem to be generically applicable in construction projects. Ongoing application of these lessons in Dutch projects proves this conclusion.

ACKNOWLEDGEMENTS

The authors are grateful to all professionals who have been interviewed, or who otherwise contributed, during performing the Geo Risk Scans in the five infrastructure projects.

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