Eight Things Successful Geotechnical Risk Managers Do

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Abstract. Looking back over a period of 10 years of underground works, geotechnical risk management has matured and has definitively contributed to the success of geotechnical projects in Rotterdam. But, what exactly was it that made geotechnical risk management successful? Looking back, and analysing the process, 8 habits of the (geotechnical) risk manager can be distinguished which made the Rotterdam approach successful.

Keywords. Risk management, risk appetite, hazard levels, risk allocation, monitoring

1. Introduction

Starting in the late eighties of the last century, in Rotterdam some large infrastructural projects were developed in the city centre. Amongst them a 3 kilometer long railway tunnel (the Willemsspoortunnel) and a 11 kilometre long subway extension (the Beneluxlijn). Facing difficult subsoil conditions in combination with work being carried out in the city centre, special attention was given to geotechnical monitoring, including assessment of geotechnical risks. These two projects laid the cornerstone of what now is a successful geotechnical risk management system.

In early 2000 preparations for RandstadRail and Rotterdam Central station started. For Rotterdam, the large-scale redevelopment of one of the most important railway junctions in the Netherlands was the reason to modernise the old passengers’ terminal, Central Station, including the entire area surrounding the city’s station. The modernised station terminal, Rotterdam Central, is now much more than in the past - more than just a railway junction, it is also an important motor for current and future city development. In figure 1 a picture of the transformation of the city’s stations surroundings is shown.

RandstadRail is an entirely new light-rail connection between the cities of Rotterdam and The Hague, the seat of the Dutch parliament. Rotterdam is the first city in the Netherlands where a tunnel has been realised by means of shield tunnelling in a city region. An underground station (Blijdorp) has also been constructed as part of this new metro line. In figure 2 the building pit of the Blijdorp station is shown.

Figure 1. Building pit around central station
The bored tunnel consists of two single-track tunnels with a 6.5 metre outer diameter and was realised in soft clay and sand at an average depth of 25 metres below ground level. The length of each tunnel is 2.4 kilometres.

Looking back over a period of 10 years of underground works, geotechnical risk management has definitively contributed to the success of the projects. But, what exactly was it that made geotechnical risk management successful? Looking back, and analysing the process, 8 habits of the (geotechnical) risk manager can be distinguished which made the Rotterdam approach successful. These are:

1. They know their risk appetite;
2. They make plans and are well organised;
3. They make sure risks get attention;
4. They are honest about the unknowns;
5. They put on their boots;
6. They are well aware of the financial aspects of geotechnical risk management;
7. They incorporate and stimulate criticism in the project.
8. They get some royalty to open the project.

2. Know your Risk Appetite

2.1. What is Risk Appetite?

Risk appetite is the amount of risk a company is willing to pursue in order to run a profitable business. With regard to geotechnics, risk appetite means the amount of risk that can be pursued with regard to the surrounding objects. In an economical context risk appetite usually is financially orientated, in geotechnical engineering risk appetite is generally related to displacement of both ground and structure.

Since the design of the geotechnical structure itself is regulated by international standards and safety factors the key issue for determining geotechnical risk appetite is the environment. To what amount of risk can the environment be exposed to? Environmental risk tolerance is reflected in the design of the geotechnical structure. A low risk tolerance means a heavier dimensioned structure in order to keep (ground)displacement within limits. Another important parameter determining the design of the geotechnical structure is the amount of uncertainty in soil conditions. The more uncertainty, the heavier the construction should be designed.

In Figure 3 the concept of risk appetite and risk tolerance is explained.

Which steps should be taken to determine risk appetite?

2.2. Steps to Determine Risk Appetite

2.2.1. Influenced Area

Determine the area to be influenced by the geotechnical structure. Take into account noise, vibrations, soil displacements caused by the works and groundwater level changes. Make an inventory of geotechnical risks.

2.2.2. Objects in the Influenced Area

What and who is present in the area to be influenced? Let me give you some examples of the different kind of objects that were present along the RandstadRail bored tunnel.
Monumental buildings require a different approach than recently build appartments. Hospitals where precision surgery is executed have a limited tolerance regarding vibrations. This also counts for financial datacentres. Appartment blocks from the ninetenthirties, founded on wooden piles and being sensitive for changes in groundwater levels. Risk tolerance of a busy railway connection between Rotterdam and Utrecht was determined by the safety regulations of the railway owner. Special care was given to a posh hotel where international tennis players stayed during a tournament. The hotels risk tolerance for noise was particularly low.

2.2.3. Legal Compliance

With regard to the environment legal regulations determine groundwater flow rates and the acceptable lowering of the deeper groundwater levels.

2.2.4. Risk Perception

Risk perception is the subjective judgment that people make about the characteristics and severity of a risk. This means that the risk of structural damage to an apartement block 50 m off a building pit will be judged differently by the owner of the block than by the contractor.

Although not always very rational, risk perception is a factor not to be neglected. Disregarding it can cause severe opposition to the project. Instead it should be managed using communication skills and being transparent about works, risks and how these are mitigated.

2.2.5. Political Sensitivity

Since the public acceptance of risk tends to diminish and claim culture increases politicians tend to get nervous when they personally might be harmed by risk. This may cause risk aversion, resulting in a low risk appetite and an over dimensioned structure. Also in this case risk communication is important. To avoid ill-founded mitigation measures politicians are on a regular basis informed about the risks associated with the works and the way these risks are controlled.

2.3. Resume

The recommended steps to determine risk appetite start with 3 ‘hard’ technical points:

1. Determining influenced area and geotechnical risks;
2. Make an inventory of the objects presents in the influenced area and the activities taking place. Get in touch with the stakeholders and consult them about their attitude towards risk, their risk tolerance;
3. What are the legal compliance factors.

The last two points are ‘soft’ human factors:

4. Keep in mind the risk perception of those being exposed to risk and incorporate this in a lower level of risk appetite or invest in risk communication;
5. Be aware of political sensitivities and risk aversion, make sure a rational consideration can be made between a low risk appetite (with financial consequences) and a higher risk appetite with the associated controllable risks.

3. Make Plans and get Organised

Derive from both the geotechnical risks, the area likely to be influenced and your risk appetite, locations and objects from which x,y,z-measurements are taken.

Make a monitoring plan in which the choice of the measuring points is motivated. The risk tolerance and risk appetite should be reflected in the choice of hazard levels (displacement limits where from a risk point of view action is necessary). Risk appetite (S-hazard level) is brought in accordance with tolerance levels (I-hazard level). The S stands for Signaling-level, whereas the I stands for Intervention level.

The S- and I-hazard level are defined as follows:

- The S-level is a value at which raised alertness is necessary and at which mitigating measures can be taken to prevent exceeding of the I-level.
- The I-level is the level above which the damage and probability of calamity is unacceptable.
The spacing which is kept between S- and I-level is coordinated on the time which it takes to implement a mitigating measure. See Figure 4.

Furthermore, in the monitoring plan it should be stated who is responsible for taking measurements, how, with what frequency and to whom these are reported. Also important is the procedural description of action to be taken in case of exceeding S- or I-hazard level.

4. Make sure Risks get Attention

In order to prevent risk management becoming just a piece of paper (‘tick the box’) make sure there is continuous attention for risks. Nobody in the organisation should be able to escape from ‘risk based thinking’. This means that all project members should be aware of their responsibilities regarding risks. Each project level has somebody responsible for the risks (the risk owner) and those mitigating the risks. The risk owner reports to the next level, where he becomes the person mitigating the risks and roles are different. The responsibility of the risk manager is to implement a reporting structure throughout the project organisation and to make sure that risks get their own agenda item in meetings.

In RandstadRail there was a continuous sharing of risks starting bottom up as can be seen in figure 5.

RandstadRail meetings on site were on a weekly base. Operational risks got a lot of attention. On a monthly base the most important risks were reported to the project leader and monitored. On a quarterly base risks were reported on the strategic level.

A risk manager was responsible for the framework of the risk management system and for the implementation of the system in the project. The risk manager contributed in the making of risk files on each project level and provided a reporting structure within the project.

5. Be Honest About the Unknowns

Since geotechnical engineering involves working with soil, you’ll be left with some uncertainty in the way structure, surroundings and soil interact. Since the concept of working in and with a medium which is not 100% controllable is a possible risk for political reputation and hard to understand for citizens, risk communication should be an integrated aspect of the risk management system. The purpose of risk communication was to create risk awareness on the strategic level (zero risk is not possible) and to reassure inhabitants that all necessary precautions were taken.

The client (Rotterdam municipality) was frequently informed about the choices made in the design process, the corresponding risks, the mitigation measures and the monitoring program. During construction, risks were reported to the client on quarterly base and politicians also visited the building pit.

The same strategy was adapted regarding the inhabitants living alongside RandstadRail. They were frequently informed about the works, invited into the building pit and tunnel and, if
desired, monitoring results were provided to individuals. The message being: ‘We’ve nothing to hide’.

6. Put on your Boots

A successful risk manager puts on his boots and steps into the mud of the building pit. Also during bad weather. The workers on site usually have a clear vision for small disruptions which might become the root cause for bigger events. For example, in one of the building pits a supervisor noticed that during the digging of the trench for a diaphragm wall the crane driver lacked experience. This might have caused irregularities in the wall itself, giving rise to (severe) leakage and damage to building pit and surroundings.

Visiting the pit makes its more easy to see and understand risks faced by construction workers. Furthermore, getting out of your office provides a listening ear for workers and so far unnoticed risks probably come your way more easy.

The sites of RandstadRail and Rotterdam Central were visited at least once a month, sometimes combined with the inspections of the risk controller of the insurance company.

7. Financial Aspects

Risk management comes with financial aspects. In order to be able to implement mitigating measures to prevent risks from happening or to diminish damage in case a risks occurs you’ll need a dedicated budget.

7.1. Determining a Budget

For RandstadRail and Rotterdam Central the budget was calculated using a probabilistic approach. In order to perform the analysis all the collected risks were provided with a probability and a financial impact. Using this input a distribution of the total financial risk was made and from this distribution a budget to mitigate or repair risks during construction was derived. The amount of money reserved to cover your risks should reflect your risk appetite. A risk averse risk appetite comes with a risk budget that should give a 85% security that the budget is enough to cover the financial impact of occurring risks, whereas a in case of a neutral risk appetite the probability of exceeding the risk budget is 50%. This principle can be seen in figure 6.

![Figure 6. Choosing a risk budget](image)

(With each risk evaluation cycle a new risk budget was calculated, based upon the actual situation. New risks, changed risks (impact or probability) or expired risks were incorporated in the calculation.

7.2. Labelling a Risk Budget

Projects have to deal with all lot of (financial) uncertainties, amongst them risks. To prevent the risk budget being used to cover all kind of unforeseen costs, not being risks, make sure the budget is labelled and that the extra costs which arise during construction are labelled as well. A close relationship with financial control should be pursued.

RandstadRail and Rotterdam Central used the following generals labels for extra costs:

- Deviations from original scope initiated by the client.
- Omissions in contract or in design.
- Risks.

The continuous cycle of evaluating the risk budget and labelling of budget and costs made possible a thorough financial control, eventually resulting in a positive financial project balance.
8. Incorporate and Stimulate Criticism

To keep a project from tunnel vision, groupthink and optimism bias opinions from outside the project should be taken into account. In the RandstadRail and Rotterdam Central project criticism and reflection was organised by means of frequent technical reviews, visits to other sites, and reflection sessions with universities. Furthermore the input of the risk controller of the insurance company was used to improve the quality of risk mitigation.

9. Get Some Royalty to Open the Project

Deadlines are necessary to manage a project. However, certain deadlines are more important than others! The foreseen opening of the new Rotterdam Central railway station by the King Willem Alexander (figure 7) in March 2014 certainly speeded up things and made the implementation of mitigating measures more easy. What we learn from this in terms of risk management is that a shared interest combined with outside pressure is a powerful tool in risk management.

Figure 7. Opening of the new station by the King, Willem Alexander