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The Geo-Impuls Programme reducing geotechnical failure in the Netherlands

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ABSTRACT: Last year in the Netherlands a 5-years development programme, called Geo-Impuls, started with the ambitious goal to half the occurrence of geotechnical failure in our civil engineering projects by 2015. This paper describes the sense of urgency to start this joint industry programme and the way it is organized, together with the geotechnical community of the Netherlands.

Twelve distinct solutions have been distinguished along five themes:

- geo-engineering in contracts
- implementing and sharing of existing knowledge and experience
- quality of design and construction processes
- new knowledge for Geo-Engineering in 2015
- managing expectations

In order to accomplish the goal a '*new working method'* is proposed which will be based on a combination of the following measures:

- apply *geo risk management (GeoRM)* explicitly during all phases of realizing the project
- practise the *geo-principles* in the project
- apply the *tools* developed by the Working Groups in the project

Finally a qualitative approach has been described, how to monitor the goal via three parallel tracks.

Keywords: Risk Management, Infrastructure, Geotechnical Failure, Geo-Impuls

1 INTRODUCTION

The Netherlands are located in a Delta area where the rivers Rhine, Meuse and Scheldt flow into the North Sea. The topsoil consists mainly of peat and clay, saturated with water and the subsoil of sand often lies more than 10 to 20 meters beneath this soft topsoil. Half of the country lies below the sea level and is protected by levees. The area is very densely populated and the demand for new public infrastructure is high.

Under these conditions geo-engineering plays an important role in the process of design and construction of infrastructure, such as roads, levees, bridges, locks and sluices.

Figure 1. Construction of a building pit in the Netherlands

2 SENSE OF URGENCY

Over the years, but also nowadays, huge investments have been and are made in constructing infrastructural works all over the Netherlands, many of which the Dutch are proud of, like the Delta works.

However, every now and then somewhere in the Netherlands geotechnical failure takes place during or after construction of a civil engineering project. In the past century some prominent failures took place, which were unfortunate, but which also greatly advanced geo-engineering (Barends, 2005).

In the past decade, we can mention:

- the collapse of a river dike consisting of peat
- the collapse of a canal dike near a crossing of a water pipe
- the inundation of a tramway tunnel
- collapses of several building pits
- large settlements near a subway
- the collapse of a sheet pile near a highway
- partial collapse of a confined disposal facility (CDF)
- partial uplift of immersed tunnel foundation

The consequences of these failures were sometimes severe. They caused delays in construction time, cost increases of the project, additional costs for the society and, even worse, the loss of life.

Figure 2. Collapse of a river dike consisting of dehydrated peat

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, and of geo-engineering specifically. This reputational loss affects for example the willingness of principals to start new projects with geotechnical challenges, for students to choose a study in geo-engineering, and for engineers to apply for vacancies in geo-engineering.

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). Approximately half of these costs are expected to be directly or indirectly soil related, due to unexpected and unfavourable ground conditions (Van Staveren, 2006). The main reason for this is the inherent uncertainty of the properties of the natural soil, which is much larger than those for man-made building materials, such as steel and concrete.

3 GOAL

On initiative of the Ministry of Transport, specifically Rijkswaterstaat, several meetings were held in the first half of 2009 with all relevant stakeholders within the geo-engineering sector in the Netherlands.

All parties recognized the ‘sense of urgency’ mentioned in chapter 2 and their mutual interest “to do something about it”. They agreed to create a clear and SMART goal to deal with this problem, which is:

> “The reduction of geotechnical failure with 50% in 2015”

They also agreed to give an impulse to the field of geo-engineering in the Netherlands, in order to reach this goal and to contribute in money and manpower to start and implement a special programme called "Geo-Impuls".

For this moment, the total budget of this programme amounts up to almost 6.500.000 Euros in money and manpower. The duration of the programme will span a period of five years, from 2010-2015.

Within the Geo-Impuls programme the following organizations and companies have combined forces to reach the ambitious objective:

Clients: Rijkswaterstaat, ProRail, the municipalities Amsterdam, Rotterdam, Utrecht and the Hague, Province of Utrecht.

Contractors: Strukton, BAM, Boskalis, Heijmans, KWS, Van Hattum & Blankevoort, Van Oord, Ballast Nedam, Dura Vermeer, NVAF

Engineers: Arcadis, Witteveen+Bos, DHV, Tauw, Movares, Fugro, Royal Haskoning, Grontmij, CRUX.

Knowledge institutes: Deltares, CURNET (COB, CUR B&I), TUDelft, CROW.

Figure 3. Official start of the Geo-Impuls programme

4 GEO-IMPULS PROGRAMME

During the meetings, which were held in the first half of 2009 with all relevant stakeholders, all kind of causes of geotechnical failure were identified, analyzed, and discussed.

Within this context, geotechnical failure has been defined in a broad sense, as resulting into:

- delays in construction time
- cost increases of the project
- additional costs for the society as a whole
- the loss of life
- damaged reputations

Also, all kind of possible measures to prevent these failures were presented. In the end the measures proposed could be clustered into five themes:

- geo-engineering in contracts
- implementing and sharing of existing knowledge and experience
- quality of design and construction processes
- new knowledge for Geo-Engineering in 2015
- managing expectations

5 TWELVE DISTINCT SOLUTIONS ALONG FIVE THEMES

Eventually, all proposals were ranked by assessing the effect of a proposal in reducing geotechnical failure and by assessing the amount of "energy" present at the stakeholders, to actually participate to a team which would realize that proposal. This process lead to a final choice of 12 specific projects fitting in one of these five themes:

Geo-Engineering in contracts

- Allocation of geo-engineering risks in projects

- Soil investigation before and during tendering: producing a widely supported recommendation for risk-based soil investigations for construction projects
- Process specifications for geo-engineering in contracts: minimum specifications based on explicit geotechnical risks to control building contracts

Implementing and sharing of existing knowledge and experience

- The implementation and transfer of a risk-based approach to acquire an insight in the geotechnical risks of projects at an early stage
- International cooperation; knowledge exchange, focus on the Geo-Impuls programme and geo-technical risk management

Quality of design and construction processes

- Quality in design and construction; how to link up two different "worlds"
- Observational Method; robust en cost-effective projects based on measurements in combination with risk-based scenarios
- Training; how to educate and train practicing geo-engineers as well as students

New knowledge for Geo-Engineering in 2015

- Quality control for elements built on site; how to trace imperfections at an early stage
- Reliable sub-surface model; a better picture of the sub-surface by combining and improving measuring and interpretation techniques
- Long-term measurements; a better understanding of time-dependent geotechnical factors by comparing 'real-time' measurements with predictive models

Managing expectations

- Communication within a project to improve the reputation and positioning of the geotechnical sector

In this programme the development of new knowledge is only a relatively small part of all planned activities. A lot of attention will be paid to the transfer and application of existing knowledge, as well as to education and training. This observation also was made by Van Tol, when he analyzed the causes of failure of 50 building pits (Van Tol et al, 2009). In more than 60% of the cases the failure was due to not (correctly) applying existing knowledge.

6 ORGANIZATION

Starting from the second half of 2009, a sector wide Steering Committee carries the responsibility of the Geo-Impuls programme. Each member from this Committee represents all stakeholders from a specific part of the geo-sector: clients, contractors, dredgers, consultants and knowledge institutes.

Moreover, each member of the Steering Committee volunteered to be 'ambassador' of a specific project, where results of the Working Groups will be applied and tested on their effectiveness.

The daily implementation of the programme has been assigned to a Core Team, being the leaders of the twelve Working Groups as mentioned earlier. Altogether, more than 100 persons are working within the programme. The Programme Bureau is managed by Deltares.

Every year a so-called "Mini-Top Conference" is held, during which the progress of the work is presented to the Directors of all stakeholders.

In order to keep the Steering Committee alert during the execution of the programme for new developments and new insights, the quality of the work is monitored and judged by several independent persons.

The Steering Committee has invited an independent consultant on risk management and also a member of Young Professionals 'de Nieuwbouw' to play this role. Moreover, an International Review Board will be installed (see chapter 8).

7 INTERNATIONAL CO-OPERATION

In the Working Group "International Co-operation" it is proposed to establish contacts with countries who can be compared with the Netherlands regarding density in population, weak soils, and complex infrastructure in delta areas. Such countries are typically dealing with similar geotechnical problems as the Dutch.

The idea is to contact all relevant stakeholders in these countries, such as governmental bodies, contractors, consultants and knowledge institutions who feel connected with the goals of the Geo-Impuls programme and are willing "to combine forces".

Co-operation can be realized by the exchange of knowledge (in both directions), by the creation of liaisons (both personal and organizational) and by brainstorming about similar geotechnical problems and solutions.

Although it is not the main goal, personal contacts during the programme may lead to new alliances between organizations or enterprises of different countries. The meetings may take place in their own country and by video-conferencing.

When several countries have been visited and showed their willingness to co-operate, their representatives are invited to participate in an "International Review Board" which will meet every year in the Netherlands.

Figure 4. Visit of the geo-centrifuge at PARI, Japan

The "financial formula" of these projects will be the usual arrangements regarding Memoranda of Understanding (MOU's). Both countries will be responsible for their own expenses, regarding e.g. the costs of travelling and hotels. No money will be transferred from one country to the other and vice versa. Extra funding from other research programs is of course possible but will be spent in the country where the budget has been allocated.

8 INTERNATIONAL REVIEW BOARD

The International Review Board will consist of representatives of stakeholders from different countries, including the Netherlands, with expertise in the entire field of geo-engineering and risk management.

The Board will meet yearly in the Netherlands at the same time when all Working Groups of the Geo-Impuls programme present their results to the Steering Committee. The Board is invited to discuss with the managers and engineers and show their views on these results. In this way, the Working Groups will be provided with valuable international feedback, information, and ideas about their actual and future approach. This exchange of knowledge may benefit all parties involved.

The Board will advice the Steering Committee on the general approach of the programme and of the quality of the results of the project teams. Their review may lead to recommendations, upon which the Steering Committee will lean strongly and which can modify the programme.

The full installation of the Board will take place in a number of steps in time, starting with Japan and the USA and may be seen as a kind of "growth-model".

9 ELEVEN GEO-PRINCIPLES

In time, the Working Groups will produce a large number of intermediate and end results, like reports, software, data, instruments and guidelines. However, we believe that the production of only *'tools'* will not be sufficient to reach our ultimate goal. We feel strongly that also a change in '*attitude and behaviour'* of all parties involved will be essential.

Usually, it is assumed that behavioural change is achieved by formulating rules, with which all parties have to comply. However, this rule-based approach may lead to a complex system of describing and en-

forcing a large number of rather fixed rules. Such a system lacks flexibility and adaptiveness, which is required because no civil engineering project is exactly the same. Moreover, obligations to apply fixed rules result often in resistance of experienced professionals, rather than in a change of their attitude and behaviour.

That is why we have chosen for a more innovative principle-based approach, which aligns with developments in the organization sciences. We gratefully use the principles already formulated by the ISO-31000 RM Guideline. When applied to geotechnical engineering, these principles state that sound engineers should:

1. Create and protect value
2. Participate in all project phases
3. Participate in decision making
4. Address uncertainty explicitly
5. Work systematic, structured, and timely
6. Apply the best available information
7. Work tailored within the context and objectives of the project
8. Take human and cultural factors into account
9. Work transparent and inclusive
10. Be dynamic, iterative and responsive to change
11. Facilitate continuous improvement of the project organization

The next challenge will be to formulate and translate these by definition abstract principles into concrete geotechnical guidelines for the entire geotechnical community. We anticipate that it will be useful to elaborate on each geo-principle on different levels.

The geotechnical professional will have a different interpretation of each principle than the project organisation or the geo-sector as a whole (CUR Bouw & Infra, 2010). On each level (so-called micro-, meso- and macro-level) the question will be "What can and will I contribute to this principle, in order to contribute to a successful project?"

10 GEO RISK MANAGEMENT

As described earlier, the development and application of tools is important, as well as creating the right attitude and behaviour of all persons involved. However, equally important will be to practise a risk-based approach in all phases of realizing the project (Van Staveren, 2006).

In the Netherlands, RISMAN is a well known risk management approach. Specifically for the geotechnical sector, this method has been further elaborated into the GeoQ concept. Though risk analysis plays an important part in this approach, managing and controlling the risks is the ultimate goal and needs even more attention (Van Staveren, 2009).

The six generic steps of this approach are: (1) setting project objectives and gathering project information, (2) identifying risks, (3) classifying risks, (4) remediating risks, (5) evaluating risks, (6) mobilizing all relevant risk information to the next project phase by a risk register.

When applying geotechnical risk management (GeoRM), multiple tools and instruments are available such as Risk checklists, Electronic Board Room risk classification sessions, Risk allocation practices, Observational Method, Risk based soil investigation and Geo Risk Scans. At Rijkswaterstaat, in recent years we applied Geo Risk Scans in a number of large projects with great success (Van Staveren et al, 2009).

We believe that GeoRM will fit seamlessly in our projects, combining the expertise of geo-engineering and risk management with daily project management.

11 THE NEW WORKING METHOD

In order to accomplish our goal we believe that a sort of '*new working method'* is needed. This new working method will be based on a combination of the earlier mentioned views:

- apply *geo risk management (GeoRM)* explicitly during all phases of realizing the project
- practise the *geo-principles* in the project
- apply the *tools* developed by the Working Groups in the project

Furthermore, it is essential that this new working method will be accepted and adopted in our geotechnical community, by individual professionals and managers, as well as in projects and in organizations. Otherwise, the gained reduction in geotechnical failures will not be durable in time. Possible ways of this type of assurance are:

- knowledge application in new projects
- documenting knowledge in manuals and guidelines
- knowledge transfer by education and training
- clients applying risk based contracts and inspections
- contractors demanding a risk based approach of their subcontractors

12 MONITORING THE GOAL

The goal of the Geo-Impuls Programme "halving geotechnical failure in 2015" proves to be very attractive because of its simplicity, focus, ambition and understandability. Monitoring this goal and making it SMART, however, is far from simple. And yet, it is one of the most frequently asked questions by sponsors, public, and press.

After ample discussion, the Steering Committee has decided not to choose for a quantitative approach. Reason for this is the fact that the information, necessary to perform this calculation, simply is not available, or incomplete, or only can be obtained with great efforts. The chosen qualitative approach will be further elaborated via three parallel tracks:

- *Actual* analysis of geotechnical incidents as published in the trade press, between 2010 and 2015.
- Analysis of the *perception* of geotechnical incidents by geotechnical professionals and the public, by means of surveys in 2011, 2013 and 2015.
- All knowledge and tools of the Geo-Impuls will be implemented in five selected projects. Between 2010 and 2015 the *effects* of this implementation (absence or presence of geotechnical failure) will be monitored.

All tracks will start with a zero measurement, followed by progress measurements. M.Sc. students of the Construction and Engineering Department of the University Twente are now further developing this qualitative approach.

By combining all of these results, obtained by monitoring these three tracks, we believe that we really can demonstrate the effectiveness of the Geo-Impuls Programme, as well as our contribution to society, by substantially reducing the occurrence of geotechnical failures.

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