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Introducing a Dutch guideline on using the Observational Method

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Abstract. In the Netherlands research has been performed on the Observational Method, aiming at a wider use of the method in the design of underground and infrastructural construction works. This paper summarizes the guideline that was output of the research, providing a clear definition, an overview of obstacles and pre-conditions, practical recommendations on how to make a safe design while using the principles of Observational Method within the context of the Eurocode 7 and practical recommendations on how to organize the method during construction.

Keywords. Observational Method, Geo Risk Management, Guideline, Eurocode 7, Design, Organization

1. Introduction

The Observational Method can produce savings in cost and planning on engineering projects, without compromising safety, and can also benefit the geotechnical community by increasing scientific knowledge. In some countries the Observational Method is frequently used, see for example Britain with famous papers by Powderham (1994) and Patel et al. (2001) and the CIRIA report 185 (1999) and France with the Irex-RGCU guideline by Allagnat (2005). In many other countries, such as The Netherlands, the method is applied in specific cases only.

When designing a project with the Observational Method often discussions start about permissions and desirability, although Eurocode 7 allows the use of the method. Also, many papers in literatures have described procedures on implementing the Observational Method such as Powderham and Nicholson (1996) and the guidelines mentioned above. However, in practice it was felt that practical guidance on using the method was missing.

This is also seen as a missed opportunity, since the method can lead to robust and cost-effective projects. It provides projects with opportunities in coping with uncertain soil conditions.

Following the above, in the Netherlands a working group has performed research on the Observational Method as part of the GeoImpuls initiative, aiming at a wider use of the method in the design of underground and infrastructural construction works. Objectives of the research include (1) gaining an overview of obstacles and pre-conditions for applying the observational method, (2) practical recommendations on how to make a safe design while using the principles of Observational Method within the context of the Eurocode 7 and (3) practical recommendations on how to organize the method during construction. All results are based on the evaluation of several case studies in the Netherlands and are placed in a Geo Risk Management context. A Dutch guideline on the application of the observational method in practice (GeoImpuls, 2015) is output of the working group.

This paper describes the main points in this guideline and does not intend to cover all topics. It is assumed that the reader understands the basics of the Observational Method. For further reading we refer to the guideline (Geoimpuls, 2015) itself and the CIRIA report 185 (1999).

2. The Observational Method

2.1. Definition

The Observational method uses an interactive process of design, construction control, monitoring and (if necessary from monitoring results) adjustment of the design and/or construction method. The method thus enables adjustments of the design during the construction phase. The method can be used in case of uncertainty about the geotechnical assumptions.

Confusion on the Observational Method starts with differing interpretations and definitions of the method. In the CIRIA report 185 and Irex-RGCU guideline definitions are provided. They provide a good basis, but still tend to be confusing. In order to gain uniform understanding, the Geoimpuls working group identified three essential points that all need to be met for the Observational Method. (1) Before the construction phase, the design scenarios need to be determined. (2) Measurements provide insight in the behaviour of ground, construction and/or interaction with the environment. The results of the measurements (that need to be available in time) determine whether a switch of scenario is necessary. (3) These measurements are executed during the construction phase.

In this context, the following three situations are not perceived by the authors as the Observational Method. These consist (1) only using monitoring without active control, decision moments and prior identified measures, (2) execution of load tests on piles or anchors since they normally are done before the construction phase (3) monitoring and fall back measurements only after problems occurred during construction since this is using the Observational Method as a 'best way out' while we consider the method as an a priori design method.

2.2. Geo Risk Management context

The Observational Method is a design method that fits well within the trend of using Geo Risk Management. GeoRM targets at gaining control over the ground uncertainties. It is a cyclic process that continuously, explicitly, structured and communicative deals with risk in order to realize project objectives as effective and efficient as possible.

When using the Observational Method one is forced to use the GeoRM principles. In order to make a good design one needs to make failure mechanisms and other risk explicit and account for them in the monitoring programme. Communication between the design team and construction team is a key element of the method.

3. Obstacles and Preconditions

In Korff et al. (2013) the outcomes of a SWOT analysis of the Observational Method were described. The working group continued on this analysis and opportunities and threats have been formulated.ased on the analysis Go / No-go criteria have been identified. The Go-criteria plead for using the method, when they are present in the characteristics of a certain project. The No-go criteria form the opposite. A third category comprises elements that are essential to be guaranteed in a project. They are not per se a No-go since they can be positively organized.

Go:

- Multistage projects and/or projects with an incremental construction process that enables continuous learning.
- Presence of risks with low, but unacceptable a priori probability of exceedance and significant consequences.
- Contractually integrated responsibility for both design and construction, preventing discussions about allocation of cost and profit.
- High ground heterogeneity and/or uncertainty in failure mechanism, preventing too conservative parameter choices.
- Displacements as leading design characteristic.
- Short project duration in relation with beneficial short term behaviour of soil.
- Critical attitude of stakeholders related to the project, where the Observational Method can be used as a way of communication.
- Although the authors do not consider the use of the method in a 'best way out' situation as real Observational Method, it still is a good situation in which monitoring and counter measures are very helpful.

No-go:

- Too little time between measurements and measures,
- Quickly changing loads.

- Failure mechanism/parameter is not measurable. Change of failure mechanism during construction.
- Measurements only useful after failure.
- Costs for changes during construction are higher than benefits minus costs for monitoring.

Essential to guarantee:

- Good communication between design team and construction team.
- Cooperation of licensing authorities.
- Sufficient time available for making the design.
- Flexible and risk based culture.
- Invest in calculation methods that make it easier to use the Observational Method.

4. Designing with the Observational Method

4.1. Planning a project with Observational Method

A design with the Observational Method is different from a traditional design. Traditionally, the safety of a design is approved using calculations and analyses. When using the Observational Method, two components are added to the design (Figure 1).

Different scenarios are identified. All scenarios (the start scenario, as well as the fall back scenarios) need to be analyzed and approved to be safe within the boundaries that are controlled with the measurements. This means that more than one design needs to be detailed and approved.

Besides this, the design explicitly consists of the contractors working plan that controls the scenarios. Monitoring is an essential part of this plan. It needs to be clear which parameters are to be measured and what the limits are to switch to another scenario. This puts high demands on a good organization and communication to ensure timely decisions to switch between scenarios. The Observational Method thus introduces a ‘human factor’ in the design. It needs to be ensured that this ‘human factor’ will function in practice.

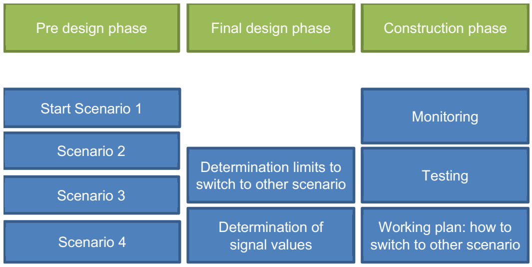

Figure 1. Scheme of working process Observational Method

4.2. Steps

The following steps, that can be taken when using the Observational Method, help to design and construct efficiently with a demonstrable level of safety by using objective (quantitative) design models.

4.2.1. Risk analysis

Geo Risk Management should be applied. In a risk analysis the relevant failure mechanisms of (parts of) the construction are identified. The development of failure in time shall be described.

4.2.2. Compose the scenarios

After an assessment of the likelihood of the limit states of failure mechanisms, a calculation is being made of the behaviour of the construction and the consequences of failure. Fall back options are defined as alternative scenarios. This step includes the decision for the set of ground parameters that are to be used (see chapter 4.3.1)

4.2.3. Determine the level of safety

The level of safety is controlled for every scenario by analysis of the ultimate limit states (fracture, collapse, loss of vertical equilibrium, occurrence of a mechanism or failure due to fatigue) and serviceability limit state (deformations, vibrations, cracks or damage that adversely affect the use).

The level of safety of all scenarios is determined or verified using the standards. The Observational Method is not meant to adjust the level of safety by lowering the partial factors. The partial factors are necessary to cover the variation in representative loads and in uncertainty in the load distribution within a construction. The partial factors are also necessary to cover model uncertainty and variation in ground characteristics.

4.2.4. Determine the measurand

The descriptive measurand (the critical parameter) is determined for the critical limit state.

4.2.5. Monitoring

Monitoring of the measurands is used to watch the behaviour of the start design scenario that is used. Normal but essential demands for monitoring exist. Reference is being made to the Dutch guideline for monitoring (CUR 223, 2010) that is published by Bles et al. (2009 and 2010).

During construction a load situation for the representative (construction)loads exists. The prediction of the structural behaviour in measurable quantities must be adjusted accordingly. The forecast of the behaviour of the construction needs to be adjusted to this situation, and used to determine the limit values for the measurements.

4.2.6. Reviewing and switching

Based on the observations and monitoring results, regularly judging of the current scenario needs to be made. If limit values are exceeded, a decision for switching to the fall back scenario needs to be made.

4.3. Safety approach

4.3.1. Determine set of ground parameters

When using the Observational Method basically the critical design parameter value can be freely chosen and used in a scenario. For non-critical ground parameters, characteristic values need to be assessed according to the normal methods in Eurocode 7.

The more conservative the choice for the critical ground parameter (a value to the left of the probability density function of the parameter), the smaller the chance that a switch needs to be made between scenarios. However, also profit in comparison with a traditional design will be smaller, whereas extra costs still are made due to using the Observational Method. When making a more optimistic choice for the parameter (a value to the right of the probability density function) the following points need to be considered:

- It should be demonstrated (as always is the case when using the Observational Method) that monitoring can still be used to detect in time whether a switch to another scenario is necessary. The likelihood of an (early) switch between scenarios is large. This might make it difficult to have enough measurements to decide for a switch.
- A switch has consequences for construction in terms of extra costs and planning challenges. It should be assessed whether the high likelihood of a switch together with the extra costs that are already made for designing with the Observational Method, outweigh the profit. An early switch might also be detrimental for trust in the method (although still safe).

Although the choice for the parameter set is open, it seems to be logical to choose a value that is equal to or safer than the presumend average value. This is also recommended by CIRIA report 185 (Nicholson et al., 1999), Powderham (1994, 1998) and Muir Wood (2000). Such a choice enables a design that is less conservative than a traditional design, with an acceptable likelihood that a switch to another scenario is necessary. In the end, the consultation between construction and design will be very important to make an optimal choice. This choice therefore is project specific.

4.3.2. Verifying the level of safety

Starting point of Eurocode 7 is the prevention of limit states to be exceeded. When using the Observational Method this is verified using the behaviour of ground and/or construction. This may be related to deformations (when verifying SLS) or components in the strength calculation (when verifying SLS).

When using the Observational Method it is important to determine during the design phase which limit state is critical. Monitoring during the construction phase provides additional information about the dominant critical ground parameters in the critical limit state.

Table 1 shows the steps to take when verifying the level of safety.

5. Organizing the Observational Method

An important part of the guideline describes the professional attitude that participants in a project should display in order to benefit most from using the Observational Method. It is also a vital part in using the method in a safely manner. Every participant in the project should have a clear perspective on his or her own tasks and responsibilities, as well on the tasks and responsibilities of the other team members. Communication between team members and the other parties involved, is essential for a successful project. Table 2 provides an overview of roles and tasks.

A design based on the Observational Method requires input from both designers and constructors. During the execution of the works the designer needs to be in close contact to the constructors and the monitoring data in order to participate in decision making and if necessary perform additional analyses on the spot. The project director should be the one to decide whether to switch to a different scenario, but without coherent input from the team this becomes virtually impossible.

6. Conclusion

The authors and GeoImpuls working group are convinced that the guideline will assist in providing practical solutions for use in projects and raising awareness of the benefits of the Observational Method. To conclude, the following benefits have been identified:

- A design can be less conservative. Yet, the profit of a sharper design should outweigh the extra cost of the more extensive design and measurements during construction.
- Designing and building with the Observational Method is safe since explicit risk management is a pre-requisite. Failure mechanisms and fall back measures are designed and calculated beforehand.
- The Observational Method perfectly fits within the trend of using Geo Risk Management in infrastructural projects.
- The extensive measurements demonstrate the behaviour of the construction very well. This helps to verify whether the construction meets the requirements and standards.
- Use of the Observational Method enforces a good collaboration between design and construction. This enables a good risk transfer of knowledge and design choices.
- The results of the extensive monitoring can excellently be used to visualize the effects of a project for the surroundings. The method therefor is a good communication instrument.
- Lots of measurements are being performed. Compilation of these measurements enlarges the knowledge about the behaviour of ground and ground-construction interaction and in this way leads to a continuously learning organisation and profession.

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Table 1. Steps for verifying the limit states according to the Eurocode 7 and using the Observational Method

Verifying of SLS or ULS	Traditional design in Eurocode 7 Design Approach 3	Using the Observational Method in Eurocode 7 Design Approach 3
Serviceability Limit State (SLS)	Design using *characteristic parameter values*	**Verifying SLS when SLS is critical limit state:** (1) Calculation of SLS scenarios with *chosen dominant critical parameter values.* The other parameter values using characteristic values. (2) Determine start scenario. (3) Verification of dominant critical parameter value by monitoring the SLS (ground)construction behaviour using the existing loads during construction. Decide whether a switch to another scenario is necessary. (4) Step 3 basically is the SLS verification. If loads during construction are lower than the critical SLS-loads, an additional ‘traditional’ SLS verification is necessary using *validated dominant parameter values*. **Verifying SLS when ULS is critical limit state:** (1) Perform a traditional SLS verification..
Ultimate Limit State (ULS)	Design with design parameter values including the use of partial factors on *characteristic parameter values*	**Verifying ULS when SLS is critical limit state:** (1) Perform a traditional ULS verification. **Verifying ULS when ULS is critical limit state:** (1) Calculation of ULS scenarios with *partial factors on chosen dominant critical parameter values.* The other parameter values are the characteristic values. (2) Determine start scenario. (3) Verification of dominant critical parameter value by monitoring. Decide whether a switch to another scenario is necessary. (4) ULS verification by calculation, including partial material factors and *validated dominant parameter values*.

Table 2. Roles and tasks with respect to the Observational Method

Role	Task with respect to the Observational Method
Third parties: authorities, insurers	Approval of design
Client or main contractor	Verification of scenarios (both design and corresponding working plan, plus choice for switch moments). Also intangible risks are taken into account (eg. politics and reputation).
Decision maker (eg. project director)	Decides about switching between scenarios, informs the client and third parties and provides feedback to consultants and contractor.
Consultant / designer	Makes design and scenarios, drafts the monitoring plan, tunes with monitoring coordinator, advises the decision maker.
Main foreman	Enables an effective execution of the project, adjusts the course of action after a switch moment and releases the project.
Monitoring coordinator	Leads the measuring team, reviews measurements and data processing, provides feedback to decision maker, guards the monitoring limits and discusses the observed behavior with the consultant.
Measurement contractor	Executes the measurements and informs the monitoring coordinator.