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Tomorrow's geotechnical toolbox: EN 1997 Overview

La boîte à outils géotechniques de demain: EN 1997 Résumé des points principaux

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ABSTRACT: This paper presents the background to the development of the second generation of Eurocode, our common European set of technical rules for structural and geotechnical design. The revision is undertaken to meet new demands in geotechnical engineering looking at the coming 20 years, e.g. design in rock, dynamics, numerical methods, probability. Furthermore, the revision is performed focusing on the users' need with the main goals of; ease-of use and harmonisation. The paper highlights the steps taken to ensure that the goals will be obtained for the primary target audience of Eurocode; practitioners – competent engineers. Finally, the paper presents an overview of some of the major changes compared to the first generation of Eurocode, that will affect the practicing geotechnical engineer. Further details of the changes are presented in additional papers presented by TC250/SC7 at this conference, all named Tomorrow's geotechnical toolbox.

RÉSUMÉ:
Ce document présente le contexte du développement de la deuxième génération d'Eurocode, notre ensemble européen commun de règles techniques pour la conception structurelle et géotechnique. La révision est entreprise pour répondre aux nouvelles demandes en génie géotechnique qui se penchent sur les 20 prochaines années, par exemple la conception dans la roche, la dynamique, les méthodes numériques, la probabilité. La révision est aussi entreprise en se concentrant sur les besoins des utilisateurs avec les principaux objectifs de; facilité d'utilisation et harmonisation. Le document souligne les mesures prises pour s'assurer que les objectifs seront obtenus pour le public cible principal d'Eurocode; praticiens - ingénieurs compétents. Enfin, le document présente un aperçu de quelques-uns des changements majeurs comparés à la première génération d'Eurocode, qui affectera l'ingénieur géotechnique. D'autres détails sur les changements sont présentés dans d'autres documents présentés par TC250/SC7 lors de cette conférence, tous nommés La boîte à outils géotechnique de demain.

Keywords: Eurocode, Ease-of-use, Harmonisation, TC250/SC7

1 INTRODUCTION

The first generation of Eurocode was published between 2002 and 2007. The publication was the result of more than 25 years dedicated work from the European Commission, Member states and the engineering technical community.

It started out as alternative rules to limit obstacles for trade and by publication it was 10 thoroughly developed parts of technical rules.

The Member States of the EU and EFTA had agreed that these technical rules should serve as reference documents; 1) to prove compliance with the fundamental requirements (serviceability, safety, fire, robustness) 2) for contract specification and 3) as a framework for creating harmonized technical specifications for building products.

EN Eurocodes are reference design codes, which implies that it is mandatory for all member states to accept design according to Eurocodes and that national conflicting standards shall be withdrawn. The Eurocodes are also anticipated to facilitate trade within the union and lead to a more uniform level of safety.

Considering the status of the EN Eurocodes as technical rules that influence all civil and building engineering projects in Europe, it is necessary to ensure that the technical rules are further improved by e.g. resolving questions of interpretation. There is also a need for an evolution of the technical rules to include new methods, materials and needed requirements to ensure long-term confidence in the Eurocode. Hence, a new second generation of the Eurocode is now under development to be finalized by 2022-2025

2 HISTORICAL TIMELINE[1]

In **1975** the work with preparation of Eurocodes started as a result of a decision taken by the commission in relation to Article 95 of the Treaty of Rome. The objective was to initiate technical rules that would eliminate technical obstacles to trade and harmonise technical specification. At this first stage the rules would serve as alternative to the national rules.

The first Eurocodes were published by the commission in **1984.** To their help they had a steering Committee with representatives from the different countries.

1990 the work with Eurocodes were transferred to CEN and the intention were to publish the Eurocodes as European standards. In **1992** the publication of ENV Eurocodes begun.

2002 to **2007** the first generation of Eurocodes were published.

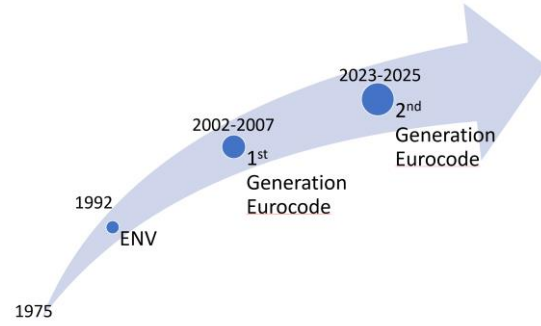

Figure 1 The historical timeline of Eurocode

In **2011** the Management Group of TC250/SC7 initiated 14 Evolution Groups with members of all Member States to study specific geotechnical topics for implementation in the revision of the Eurocode. Evolution Groups for e.g. Harmonisation, Groundwater, Numerical Methods, Ground Improvement, Ease-of-use were established and reported in 2015-2016.

2012 the European Commission addressed the M515 mandate that gave CEN the responsibility to further develop the Eurocodes into the Second generation.

2015 Phase 1 on drafting the second generation of Eurocode started with the first project teams established. Phase 2 started in 2017 and Phase 3 in 2018. For EN 1997 there are six different project teams: two in Phase 1, three in Phase 2 and one in Phase 3,

2021 all work by the project teams will be finalized and the normal formal process starts including enquiry and formal vote.

2023/24 publication of all three parts of EN 1997 is anticipated.

[1] The content of the timeline is based on information given at JRC Eurocodes webpage and tender for M/515.

3 2ND GENERATION EUROCODE

3.1 Objective

The objective of the work program that has been established by CEN/TC250 include revision of the existing codes to 1) improve ease-of-use 2) increase harmonisation 3) cover aspects of the assessment, re-use and retrofitting of existing structures and 4) strengthening the requirements for robustness.

The work program also includes the extension of the scope of the Eurocodes. In Eurocode 7, additional items were included: groundwater, reinforced soil, ground improvement, dynamic. In addition, it was clearly demanded that rock engineering shall be included.

3.2 Target audience

The second generation of Eurocode will be more user-oriented, with the primary target audience being the Practitioners – Competent engineers. The drafting is focusing on this audience, defined as *competent civil, structural and geotechnical engineers, typical qualified professionals able to work independently in relevant fields*. However, additional nine categories of audiences, such as e.g. Graduates, Experts, Product manufacturers, Clients were identified. The aim is also to include their needs, but if there is a conflict in needs, the primary target audience takes preference.

One of the strategies to fullfill the need of the primary audience is to draft the text based on common design cases, i.e. those that occure in 80 to 90 percent of all cases. The statement of intent made by CEN/TC 250 is "We will aim to produce Standards that are suitable and clear for all common design cases without demanding disproportinate levels of effort to apply them"

3.3 Ease-of-Use

For the Practitioners it is essential to have standards that are practical tool for daily design. Several possibilities for improving the Eurocodes user-friendliness have been identified in the prework done by CEN/TC 250.

The following has been listed as high-priority targets for drafting the second generation; 1) improve the clarity (use consistent language, avoid unnecessary guiding text) 2) facilitate the routes through the Eurocodes (use the same structures for all parts so that complementary requirements easily may be found). 3) avoid, if possible, the use of alternative application rules and 4) exclude rules of little practical use.

3.4 Harmonisation

National Determined Parameters, NDPs is a possibility for countries to decide on safety levels and make necessary alterations of the requirements in Eurocode in relation to geographic and climate conditions. From a geotechnical perspective, it is obvious that the national geological conditions and their variations within the country influence the requirements.

In the first generation of Eurocodes the number of NDPs became greater than anticipated. NDPs were also used in some cases not related to safety and/or geographical/climate conditions. Therefore, CEN/TC 250 has agreed that the ambition for the second generation is to increase the harmonisation and reduce the number of NDPs.

For Eurocode 7 it means that the 42 NDPs that were included in the first generation should be reduced. For EN 1997 considerate might be considered adding GDPs (Geological Determined Parameters) as a possibility to reduce the number of NDPs, since many of our needed alterations of values are linked to the geological background of the site, see *Figure 2*.

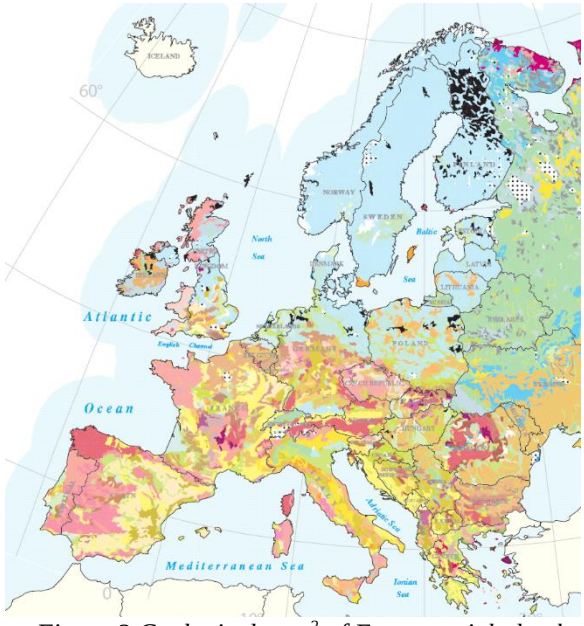

Figure 2 Geological map[2] of Europe, might be the base of GDPs.

It is a challenge to reduce the NDPs and to achieve this it is necessary to carefully consider both the content of the Eurocode and the formulation of each paragraph. It is necessary to write a standard that is not in conflict with nationally legislation in any European Country. It is also necessary to maintain consensus, so that a positive formal vote for the Eurocode is obtained by the end. To succeed, the challenge must be done pragmatically and with respect for national positions.

For each NDP, the Eurocode will give a recommended value. The Commission gives permission to each Member State to deviate from these values only if geographical, geological or climatic conditions or specific levels of safety make that necessary. Hence, it is important to try to reach a consensus on the recommended value of each NDP to facilitate the implementation.

4 2ND GENERATION EC7 MAIN CHANGES

4.1 Four parts of Eurocode to consider

The second generation of Eurocode will cover the same topics as the previous generation, but with added state-of-the-art knowledge and additional topics. However, one of the major differences that will be noted is the re-organisation of the text into a common structure for all Eurocodes. The table of contents will be essentially the same independently whether the Eurocode is covering steel, concrete or geo-technical engineering. The aim is that the re-organisation will provide an easier navigation through the text and make a clearer distinction between requirements and recommendations.

EN 1990 that will have the title Basis of structural and geotechnical design, will more clearly also cover the basis of design for geotechnical design. It is also clearly stated that is not permitted to repeat, so if written down in EN 1990 it should not be repeated in EN 1997.

As *Figure 3* is showing EN 1997 will be divided into three different parts, instead of two. One covering general rules, one focusing on ground parameters and one with specific requirements for different geotechnical structures.

The consequence for the practicing engineer will be that for design of a geotechnical construction at least four different parts of Eurocode need to be considered. EN 1990, EN 1997-1, EN 1997-2 and EN 1997-3. Depending on the load situation it might be necessary to look also at EN 1991 and if the structure is in seismic areas EN 1998 is also applicable.

[2] Dominat parent material for Soil Typological Units according to ESDAC (European soil data center). www.esdac.jrc.ec.europa.eu

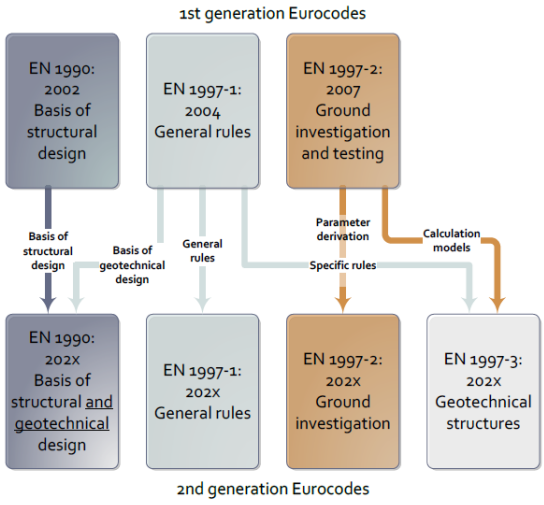

Figure 3 Re-organisation of Eurocode related to Geotechnical Engineering (Bond et al, 2019)

4.2 Verification four equal methods

Verification of limit state using calculation, with the partial factor approach, will still be the primary approach of Eurocode. However, EN 1997 clearly state that verification with prescriptive measures, testing and observational methods are equally acceptable. The observational method is especially highlighted for rock engineering. In addition, EN 1997 also open the possibility to use full reliability-based methods for verification.

4.3 Reliability management

The concept of Geotechnical Categories (GC) is revised in the second generation of Eurocode. The concept is used to classify the design situation for a specific geotechnical structure based on geotechnical complexity and consequence of failure (Consequence Class). GC is used to introduce a flexibility in the requirements, so that the amount of work related to design and checks are relevant for the considered design situation.

The main use of GC is to ensure that relevant and sufficient measures to limit the probability of errors are applied, so that the appropriate level of reliability is achieved. The GC in EN 1997 links specific measures to fulfil the criteria established in EN 1990 to obtain the specified reliability.

Figure 4 Considering the consequences and the geotechnical complexity this is Geotechnical Category 3. What measures are needed to achieve the appropriate reliability for the foundation of this bridge? (Photo: G. Franzén)

4.4 Assessment of ground properties

EN 1997-2 (Norbury et al, 2019) has been reorganised so that the aim is to give the designing engineer guidelines how to determine the ground parameters in an appropriate way. Part 2 also gives an indication of the accuracy of the ground propery depending on the choosen investigation method. For specific requirements on testing methods reference are made to standards prepared by other TCs.

4.5 Specific requirements for geotechnical structures

In the first generation of Eurocode the specific detailed requirements for each geotechncial structure were covered in EN 1997-1. In the 2nd generation these specific requirements has been moved to a separate part EN 1997-3. This to make a distinction between general rules presented by EN 1997-1 that's should be applied independently of the geotechnical structure designed, and specific rules covered by EN 1997-3 that only apply to the geotechnical structure at hand.

4.6 Rock engineering

One of the topics that has been specifically highlighted for EN 1997, is rock engineering. The first generation of Eurocode were mainly developed from the soil mechanic perspective. Drafting the second generation the aim is to include soil and rock on equal basis in the code. All general aspects in EN 1997 should be drafted with the perspective of ground, including both soil and rock.

Figure 5 Soil or rock? In 2nd Generation of Eurocode the aim is to treat both on equal basis, as ground (Photo: G. Franzén)

4.7 Dynamic loading

Another topic that has been added to EN 1997 is that it should cover foundation subjected to dynamic loading (machine foundations, wind turbines, cable masts). These topics should complement EN 1998 that is covering design in seismic areas. The drafting is ongoing, but additional paragraphs will be added to EN 1997 to cover both high frequency loading and cyclic loading.

4.8 Numerical methods

The scientific development of numerical methods are rapid, and the 2nd generation of Eurocode needs to ensure that the requirements given in the code, are still valid over 15 years.

This is a challenge and therefore the competency and validation of output is specifically emphasised for application of numerical methods. A set of rules for use of partial factors for numerical methods has been drafted in EN 1997-1. Emphasis has been put that there are a number of factors influencing the verification e.g.: discretisation of geometry, initial stress states, construction stages, boundary conditions and constitutive behaviour (Lees, 2019).

4.9 Reinforced soil

In the 2nd generation of Eurocode, Reinforced soil has got its´own clause. It will covering reinforced soil structures including reinforced fill structures, soil nailed structures, basal reinforcement for embankments and veneer reinforcement. It is a wide range of applications that will be covered by this clause, so it is a challenge to describe a set of rules applicable for verification using partial factors.

4.10 Ground improvement

Ground improvement is another new clause in EN 1997 part 3. It covers all types of ground improvement used in connection with slopes, cuttings, embankments, spread foundations, piled foundations and reatining structures.

To be able to define a set of rules for ground improvement, a classification system has been included. This system is based on two families of ground improvement; diffused (Compactive Methods, Soil Replacement, Consolidation Methods, Grouting, Deep Mixing) and discrete (Granular Columns, Grouting/mixing methods, Steel/Wood Columns and Concrete Columns).

5 CONCLUSIONS

5.1 Writing for the future

The second generation of Eurocode that now is developing will be used for many years. Publication in 2023-2025, it will take at least 10-15 years before a new major revision. Hence the text should be written for the engineers of 2035! What will the engineers working condition be? What

will the daily tools be? Considering the development on the computer capacity of the last 15 years, the code needs to be useful also for FE-analyses (and whatever comes after that....).

Efforts has been made to include FE-analyses, but not limit for methods to be developed in the coming years.

Robustness and consideration of climate change are other topics that will be considered in the standard, but still should not be limited to the knowledge we have today.

5.2 Companion papers

Additional information about the content of the Second Generation of Eurocode may be found in the companion papers presented by Bond et al. (2019), Franzen et al. (2019), Norbury et al. (2019), Estaire et al. (2019) and Lees (2019).

6 ACKNOWLEDGEMENTS

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