Eurocode 7 – an updated framework to ensure reliable geotechnical solutions

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Abstract. In a few years’ time, the 2nd generation of Eurocode will be published. The aim of the revision of Eurocode 7 is to meet new demands in geotechnical engineering looking at the coming 20 years, e.g. assessment of ground properties, design in rock, dynamics, numerical methods, probability. Users’ need with the main goals of ease-of-use and harmonisation, is the key-target for the revision. 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 paper will include an overview of some of the major changes compared to the first generation of Eurocode, that will affect the practising geotechnical engineer. In addition, some more details will be given on management measures for geotechnical reliability, assessment of ground properties and execution.

1. Introduction
A common European set of technical rules for geotechnical and structural design, is that possible to accomplish? What influence would such a set of technical rules have on the day-to-day work for the geotechnical engineers? Would it have any influence outside the engineering community?

This paper will give background information on the ongoing common European work to prepare the 2nd generation of Eurocode. The aim is that you after reading this paper could make you own opinion concerning the questions above. Is it possible to accomplish common technical rules and what will, in such case, the influence be?

2. Eurocode – common work to prepare for the future
The first steps towards a common European set of technical rules were taken in 1975 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. 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 Commission, Member states and the engineering technical community. It started out as alternative rules to limit obstacle for trade, and by publication, it was 10 thoroughly developed parts of technical rules.

The historical timeline of Eurocode that is illustrated in Figure 1, shows that since the start in 1975, it has been a continues common work to improve and further develop the Eurocode.

Already within a couple of years after publication of the first generation of Eurocode the possibilities to improve the Eurocode were identified. In 2012 the European Commission, therefore, addressed the
M515 mandate that gave CEN the responsibility to further develop the Eurocodes into the Second-generation. The objective of the new mandate was to 1) improve the ease-of-use, 2) increase harmonisation, 3) include aspects of assessment, reuse and retrofitting of existing structures and 4) strengthening the requirements of robustness.

The work-program that were established based on the mandate also included an extension of the scope of the Eurocodes. For geotechnical engineering, rock should be included on an equal basis as soil, and dynamic aspects should be treated within the code.

![Figure 1. The historical timeline of Eurocode](image)

3. **2nd generation of Eurocode – will it make any difference?**

For geotechnical and structural engineers throughout Europe, it is obvious that if there are major changes in the Eurocode, it will influence their day-to-day work. To what extent will depend on the changes and the implementation in each country.

It is however less recognized that the 2nd generation of Eurocode also could have major effects on the building sector, the local municipality, the house owner and finally for all users of transportation and houses. The effects will depend on both the final content of the 2nd generation but also on the national choices made by each NSB (National Standardization Body).

In 2003 the Commission issued their recommendation on the implementation and use of Eurocodes. The Member States of the EU and EFTA greed that these set of standards 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. Hence, it is mandatory for all member states to accept design according to Eurocodes and that national conflicting standards are withdrawn. The recommendation also encourages the Member States to adopt the recommended values of (National Determined Parameters) NDP and to contribute to further harmonization and development of the EN Eurocodes.

Eurocode sets the framework with technical rules on how to prove that a structure, road, railway or bridge is safe, functional and robust. The code will give requirements that need to be fulfilled and hence the code will influence the quality of everything that is built. This, in turn, will influence the cost of building and maintaining structures and infrastructure. So, depending on what is included in the final version of the 2nd generation of Eurocode, the result could be reduced or increased cost for constructions, that in the end will need to be paid by the citizens.

The Eurocodes aims to facilitate trade within the union and lead to a more uniform level of safety. The specific safety level that is required in each country is a national decision. But the ambition is to
reduce the number of national choices (NDPs), to achieve a common view also on safety levels. The work and decisions that are taken in the development of the 2nd generation of Eurocode will hence influence the safety, functionality, quality and cost of everything that will be built in the coming years.

4. 2nd generation Eurocode – design for the future

Considering the status of the EN Eurocodes as technical rules that influence all civil and building engineering projects in Europe, it is evident that it is necessary to ensure that the technical rules are further improved by, e.g. correcting errors, eliminating inconsistencies, 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. These are the main reason for developing a new second generation of the Eurocode.

4.1. Re-organisation

One change that will be apparent for the geotechnical engineer is the reorganisation of Eurocode, from three parts into four. The general rules that are applicable to both structural and geotechnical design are found in EN 1990. EN 1997 part 1, will give the general rules applicable for all geotechnical design, while EN 1997 part 3 will give the specific rules for some of the most common geotechnical structures. EN 1997-2 has been reorganized so that the design engineer should get requirements on determination the ground parameters in an appropriate way. For specific requirements on testing methods reference are made to standards prepared by other TCs within the standardization. The outline of the reorganization is shown in Figure 2.

In the drafting guidelines, it is clearly stated that is not permitted to repeat, so if EN 1990 states a requirement, it should not be repeated in EN 1997. The navigation in different parts of Eurocode should be facilitated by having the same basic table of content for all Eurocodes. The consequence for the practising engineer will be that for geotechnical design, 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.

![Figure 2. Re-organisation of Eurocode related to Geotechnical Engineering](image-url)
4.2. Target audience
The Practitioners – Competent engineers (Defined as: competent civil, structural and geotechnical engineers, typically qualified professionals able to work independently in relevant fields) will be the primary target audience for the 2nd generation of Eurocode. This since the main objectives is to prepare a more user-oriented Eurocode. In addition, another categories of audiences, e.g. Graduates, Experts, Product manufacturers, Clients are identified. Their needs should also be considered, but if there is a conflict in needs, the primary target audience takes precedence.

By focusing on the common design cases, i.e. those that occurs in 80 to 90 per cent of all cases, the aim is to fulfil the need of the primary target audience. 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 disproportionate levels of effort to apply them.”

4.3. Ease-of-use
For the Practitioners, it is essential to have standards that are a practical tool for day-to-day work. Several possibilities for improving the Eurocodes user-friendliness has been identified in the prework done by CEN/TC 250.

For drafting the second generation, the following has been listed as high-priority goals; 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 4) exclude rules of little practical use.

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

4.5. Reliability management
EN 1990 defines that the requirements and principles for safety, serviceability, robustness and durability set in Eurocode shall be appropriate to the consequence of failure [EN 1990, 1.1 (1)]. Hence, EN 1990 introduces flexibility in the choice of an appropriate level of reliability with consideration of consequences of failure. Consequence classes are introduced with the possibility for a national choice of a minimum level of reliability for each consequence class.

The procedure to achieve the appropriate level of reliability for avoiding failure and obtaining serviceability are according to EN 1990 [4.2 (3)]; 1) Appropriate representation of the basic variables. 2) Accuracy of the mechanical models used and interpretation of their results. 3) Prevention of errors in design and execution of the structure, including gross human errors 4) Adequate inspection and maintenance according to procedures specified in the project documentation. 5) That the rules set in Eurocode are followed in the design.

To avoid errors in design and execution, measures need to be taken to limit the probability of their occurrence [EN 1990, 4.2 (2)]. So, it is a combination of taking actions to achieve the appropriate level of reliability and to limit the probability of occurrence of errors.

In geotechnical engineering, it is not only the consequence of failure that influence the need for measures to limit the probability of errors and ensure an appropriate level of reliability. The geotechnical complexity needs to be considered, and therefore the Geotechnical Complexity Classes are introduced. There are three different classes – Low, Normal, High – depending on the complexity of the most critical design situation. The combination of the consequence of failure in terms of Consequence Class and Geotechnical Complexity Class is defined as Geotechnical Categories (GC). The concept is used to classify the design situation for a specific geotechnical structure based on geotechnical complexity and consequence of failure. The main use of GC is to ensure that relevant and enough measures to limit the
probability of errors is applied so that the appropriate level of reliability is achieved. The GC in EN 1997 link specific measures to fulfil the criteria established in EN 1990 to obtain the specified reliability.

Table 1 (NDP) Relationships between Geotechnical Categories (GC), Consequences Classes (CC), and Geotechnical Complexity Classes (GCC).

| Consequence Class (CC) | Geotechnical Complexity Class (GCC) |
|------------------------|------------------------------------|
|                         | Lower (GCC1)                       |
| Higher (CC3)            | GC2                                |
|                         | Normal (GCC2)                      |
| Normal (CC2)            | GC2                                |
|                         | Higher (GCC3)                      |
| Lower (CC1)             | GC1                                |

The Geotechnical Categories are used to specify the:
- minimum amount of ground investigation;
- minimum of validation of calculation models;
- minimum of supervision;
- minimum of inspection;
- minimum of monitoring;
- minimum of designer qualifications and experience;
- minimum amount of reporting.

4.6. Ground improvement and Reinforced Ground

Ground improvement and Reinforced ground are two areas that in the 2nd generation will be treated as separate geotechnical structures in EN 1997 part 3. Consequently, there will be common rules for these structures, that until now usually have been designed based on national praxis. It is a challenge to harmonize different praxis and to agree on common requirements on the verification. But from the discussions, eventually, there will be common acceptable rules for verification of different types of ground improvement and reinforced ground.

4.7. 2nd Generation – a standard for the future

The coming second generation of Eurocode is developed to be used for many years. After publication in 2023 – 2025, it will take at least 10 – 15 years before the next revision. Hence the text should be written for the engineers of 2030! What will the engineers working condition be? What will the daily tools be?

The development of our computers, software and constitutive models over the latest 15 years are large. Hence the code needs to be solid and useful also for FE-/DE-/etc-analyses. Actions have been taken to include FE-analyses, but not limit the requirements based on our knowledge of today.

Robustness and consideration of climate change are other challenges that will be considered in the developing the new standards.

5. 2nd generation Eurocode - a Nordic Perspective

From a Nordic point of view, it is important to influence the 2nd generation of Eurocode to ensure that our specific geology, climate consideration, our praxis and contractual requirements being recognized in the 2nd generation of Eurocode.

In the Nordic countries, we have a long tradition to cooperate between our countries, both on a project level and national level. Related to EN 1997, cooperation was established already during the work with the first version of EN 1997. However, to ensure our Nordic influence on the preparation of next Eurocode, it was decided to establish a more formal cooperation. Therefore, Nordic Mirror Group EuroCode 7 (NMGEC7) was established in January 2014. The objective of the group is to influence the drafting so that our common Nordic view on different topics is recognised.
The Nordic countries are small, and it is therefore not possible to have experts from each country in all the different tasks groups that are working on the European level. Instead, NMGEC7 decided that the Nordic representatives in the different task groups would speak for all of us. We would be five countries, but we would highlight the same common view. To be able to do that, a tradition has by now been established to meet for a two-day Nordic meeting to prepare our common view on the topics of the agenda for the coming SC7 meeting. Being well prepared for the SC7 meetings, and working together, both at meetings and between, has proven to be a key to influence the Eurocode in a positive way.

Another key to influence has been to encourage Nordic colleges to get involved on the European level. There have been six project teams with the task to draft the three new parts of EN 1997. There has been a Nordic representative in five of these teams. In a year (April 2021) the final project team draft will be available, and after that, the official procedure with enquiry and a formal vote will take place. Most of the text will be finalized by the project teams, but still, there is time to influence the final wording of the text.

6. 2nd generation Eurocode – still time to influence

Even though the Eurocode itself might approach a final format, there is still a huge amount of work to be done. The new Eurocode need to be implemented, and there is a need to develop the national annexes. In this work, there is a need for people that could get involved to ensure that the Eurocode will be implemented, so that the goal of ease-of-use and safe structures to a reasonable cost is achieved.

The intention of this paper is to highlight the work that will have a significant influence on the way geotechnical engineers will work in the future. The paper does only to a minor extent give technical details of Eurocode. If you like to know more about the details and influence the future, you should become a member of NMGEC7.

Finally, what is your opinion after reading this paper? Is it possible to accomplish common technical rules applicable for different geologies and structures? What will, in such case, the influence on geotechnical engineering be?