Proceedings of the 21st ICSMGE, Vienna, Austria, 14 – 19 June 2026. Pistrol, Adam & Schweiger (eds.)
Published by: ÖGG, Austrian Society for Geomechanics, Salzburg, Austria, ISBN 978-3-9503898-4-5
https://doi.org/10.53243/ICSMGE2026-1402

Advancing Pile Foundation Design: A Case Study on Bearing Capacity in Light of Second-generation Eurocode 7

Zsolt Szilvágyi
Geoplan Ltd., Hungary, szilvagyi.zsolt@geoplan.hu

ABSTRACT: A new generation of Eurocode standards have been developed to incorporate evolving technical and legislative frameworks. The new Eurocode 7 standards introduce several state-of-the-art calculation methods, important concepts of reliability, robustness, durability, sustainability while refining and retaining well-accepted design methods from the first generation. This paper provides insights into the impact of transitioning from the first-generation Eurocode 7 to its upcoming second-generation guidelines set to be enforced in 2028. After an overview of the geotechnical design flow in the new standards, special emphasis is put on pile design. A case study is presented from eastern Hungary, where a detailed investigation program was performed for the design of a large industrial development. Thorough analysis of CPT based pile resistance calculations have been performed to highlight the changes required by the new standards and their impact on economic and technical aspects. The benefits and drawbacks of automated calculations are highlighted. The findings offer valuable guidance for engineers transitioning to the second-generation Eurocode 7, aiding in the adaptation to more refined and performance-driven design principles. Practical recommendations are provided to ensure compliance while maximizing the economic and technical efficiency of pile foundation systems.

KEYWORDS: Pile foundation design, 2nd generation Eurocode 7, automated CPT based pile design

1 INTRODUCTION

Since the development of the first-generation Eurocode (EC) standards, ongoing technological progress, evolving legislative frameworks, and accumulated experience from their practical application have made their modernization necessary. In response, the European Committee for Standardization (CEN) has prepared several second-generation Eurocode standards, with the remaining standards expected to be completed progressively by 2027. All EU Member States are required to fully incorporate the second-generation standards into their national standardization systems by October 2027, and to withdraw the first-generation EC standards by April 2028.

The Eurocode 7 standard serves as a fundamental framework document of critical importance for geotechnical designers and related engineering disciplines. Its further development and updating are of paramount significance to all stakeholders within the construction sector, including supervisory, regulatory, and inspection bodies. This paper aims to give an overview about the design process behind Eurocode 7 and highlight the most important aspects of pile foundation design from a practical point of view through a case study.

2 FLOW OF GEOTECHNICAL DESIGN IN SECOND GENERATION EUROCODES

2.1 *Basic requirements*

In the second-generation Eurocodes, five standards regulate geotechnical design:

- EN 1990: Basis of structural and geotechnical design,
- EN 1997-1: Geotechnical design: General rules,
- EN 1997-2: Geotechnical design: Ground properties,
- EN 1997-3: Geotechnical design: Geotechnical structures,
- EN 1998-5: Design of structures for earthquake resistance: Geotechnical aspects, foundations, retaining and underground structures.

The basic requirements are that a Ground Model and Geotechnical Design Model shall be used to verify requirements of safety, serviceability, robustness and durability of geotechnical structures. To assess these, a Geotechnical Complexity Class (GCC) shall be selected, which together with the Consequence Class (CC) of the structure governs the selection of the Geotechnical Category (GC). This means, a separation has been made between the consequence of failure and the complexity of ground conditions, contrary to the first generation. This allows a clear classification of projects into Geotechnical Categories. The CC may be related to the supported structure or to the geotechnical structure itself.

2.2 *Reliability, robustness, durability, sustainability*

The appropriate level of reliability is ensured, as the selected GC specifies the amount and extent of:

- measures to achieve appropriate representation of parameters for design,
- measures to achieve accuracy of the calculation models and the interpretation of their results,
- measures to prevent errors in design and execution,
- measures to ensure appropriate implementation of design.

Robustness, durability and sustainability are important concepts that now have special emphasis in the new generation Eurocodes. Quality management is now governed by GC, defining Design Qualification and Experience Levels (DQL), Design Check Levels (DCL), Inspection Levels (IL) and Minimum Execution Class (EXC). Here the emphasis on execution and service life can be observed.

The design service life categories have been revised and now a table specifies design service life for geotechnical structures as well. The usual 50 years design service life shall be reduced to 25 years for replaceable parts of geotechnical structures (e.g. ground anchors), or extended to 100 years for structures supporting or incorporated into road or railway infrastructure, as well as embankment dams for water defense.

2.3 *Limit state design*

The main ideas of limit state design have remained intact. The definition of design situations is now supplemented for geotechnical design, to put more emphasis on:

- stages of execution, service life, repair, maintenance,
- execution methods, their impact on geometry and ground properties,
- buildability,
- anticipated changes in ground or groundwater conditions,
- anticipated changes in loading in the zone of influence.

The default method for verifying the critical ULS and SLS limit states will continue to be the partial factor method, however as an alternative, probabilistic methods may also be used instead.

For geotechnical engineers the most important changes in the glossary of the partial factor method are that:

- Limit States are now replaced by Verification Cases:
  - VC1 is for structural resistance (used both for structural and geotechnical design, formerly STR),
  - VC2 is for static equilibrium and uplift (formerly EQU and UPL),
  - VC3 is for general geotechnical design (formerly GEO),
  - VC4 is also for geotechnical design (used for the design of transversally loaded piles and embedded retaining walls and in some countries, gravity retaining structures, formerly GEO).
- Design Approaches (DA) are now streamlined into only two methods, the Material Factor Approach (MFA) and the Resistance Factor Approach (RFA).
- The term Representative Value is introduced and replaces the old characteristic value. The Representative Value is determined either as a cautious estimate or with a statistical approach (European Commission JRC 2025)

An important update is that, the use of numerical methods for design and verification is now incorporated into Eurocode 7.

3 PILE FOUNDATION DESIGN IN THE SECOND-GENERATION EUROCODE 7

3.1 *General aspects*

The clauses on pile foundation design have been fundamentally revised and improved compared to the first generation. Most importantly in addition to the clauses about single piles, Chapter 6 in Eurocode 7-3 is now dealing with pile groups and piled rafts as well. Also detailed guidance is given on actions on piles due to ground displacements such as downdrag or heave. As a novelty, the procedure for verification of limit states with numerical models has been introduced and a detailed factoring approach is presented.

The design of piled foundations can be performed by testing, calculations and prescriptive measures, as in the past. The verifications of Ultimate Limit States (ULS) and Serviceability Limit States (SLS) are defined in connection to the relevant Verification Cases (VC).

A thorough introduction about the changes have been presented in (Moormann, Burlon 2024) and a clear overview is given in the form of flow charts and design examples in (European Commission: JRC 2024).

In Hungary the most commonly used method is the pile design based on CPT and if the project circumstances allow it, or the importance of the structures designed requires it, static pile load testing is applied and in most cases the methods are then calibrated. In the following the most important aspects are summarized which are relevant for the presentation of the case study.

3.2 *Compressive resistance of single piles*

For axially loaded single piles the most important design methods are design by testing and by calculation. As earlier, correlation factors and model factors consider the spatial variability of the ground and the uncertainty of the calculation models or of the measured values (Figure 1.), However, these factors have been revised since the first generation to bring clarity and consistency throughout the chapters about different geotechnical structures.

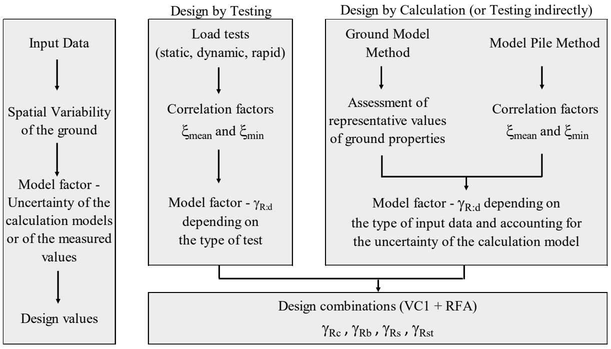


Figure 1. Verification methods for compressive resistance of single piles (redrawn after (Moormann, Burlon 2024))

The axial compressive resistance of a single pile shall be verified using:

$$F_{cd} \leq R_{cd} \tag{1}$$

where

F_{cd} is the design axial compression force,

R_{cd} is the pile's design axial compressive resistance.

The design axial compressive resistance shall be determined from:

$$R_{cd} = \frac{R_{c,rep}}{\gamma_{Rc} \cdot \gamma_{Rd,pile}} \; or \; \left(\frac{R_{b,rep}}{\gamma_{Rb} \cdot \gamma_{Rd,pile}} + \frac{R_{s,rep}}{\gamma_{Rs} \cdot \gamma_{Rd,pile}}\right) \tag{2}$$

where

$R_{c,rep}$ is the pile's representative total resistance in axial compression;

$R_{b,rep}$ is the pile's representative base resistance in axial compression;

$R_{s,rep}$ is the pile's representative shaft resistance in axial compression;

$\gamma_{Rd,pile}$ is a model factor accounting for uncertainity in the resistance model for a piled foundation; and

γ_{Rc}, γ_{Rb}, γ_{Rs} are partial factors.

It is well known in the state-of-the-art practice, that the most precise method for obtaining compressive resistance in almost all soil types is the static pile load test; this is well represented in the model factor value ($\gamma_{Rd,pile} = 1.0$ for static pile load test). Among the well-established methods for the verification of axial pile resistance by calculation, the design based on Cone Penetration Tests has the next best model factor ($\gamma_{Rd,pile} = 1.1$ for CPT based calculation using the Model Pile Method).

The partial safety factors γ_{Rc}, γ_{Rb}, γ_{Rs} depend on pile boring technology and load bearing method (compressive, tensile or transverse resistance).

The CPT based calculation shall be performed with the Model Pile Method. For design by calculation using the Model Pile Method, the representative value of resistance of a single pile shall be determined from:

$$R_{rep} = min\left\{\frac{R_{calc,mean}}{\xi_{mean}}; \frac{R_{calc,min}}{\xi_{min}}\right\} \tag{3}$$

where

$R_{calc,mean}$ is the mean calculated pile resistance for a set of profiles of field or laboratory test results;

$R_{calc,min}$ is the minimum calculated pile resistance for a set of profiles of field or laboratory test results;

ξ_{mean} is a correlation factor for the mean of the (calculated) values; and

ξ_{min} is a correlation factor for the minimum of the (calculated) values.

The aim of the correlation factors is now only to account for the spatial variability of the soil, contrary to the first generation, where it carried some risk management aspects also. Some important updates have been made regarding the correlation factors in the Model Pile Method, which is used for pile design based on CPT (Figure 2.).

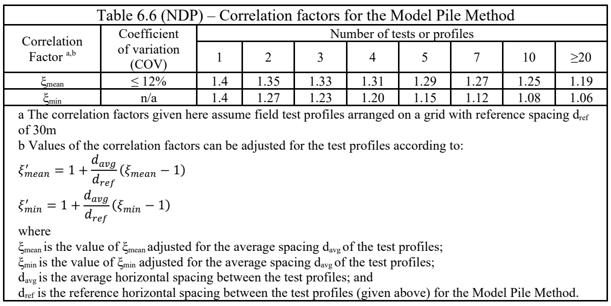


Table 6.6 (NDP) – Correlation factors for the Model Pile Method									
Correlation Factor ^{a,b}	Coefficient of variation (COV)	Number of tests or profiles							
		1	2	3	4	5	7	10	≥20
ξ_{mean}	≤ 12%	1.4	1.35	1.33	1.31	1.29	1.27	1.25	1.19
ξ_{min}	n/a	1.4	1.27	1.23	1.20	1.15	1.12	1.08	1.06

a The correlation factors given here assume field test profiles arranged on a grid with reference spacing d_{ref} of 30m

b Values of the correlation factors can be adjusted for the test profiles according to:

$$\xi'_{mean} = 1 + \frac{d_{avg}}{d_{ref}}(\xi_{mean} - 1)$$

$$\xi'_{min} = 1 + \frac{d_{avg}}{d_{ref}}(\xi_{min} - 1)$$

where

ξ_{mean} is the value of ξ_{mean} adjusted for the average spacing d_{avg} of the test profiles;

ξ_{min} is the value of ξ_{min} adjusted for the average spacing d_{avg} of the test profiles;

d_{avg} is the average horizontal spacing between the test profiles; and

d_{ref} is the reference horizontal spacing between the test profiles (given above) for the Model Pile Method.

Figure 2. Correlation factors for CPT based calculation by the Model Pile Method (from FprEN1997-3:2024.TC250 (E), Table 6.6)

First, the updated table now only allows the use of the correlation factor ξ_{mean} established in the first generation, if the coefficient of variation of the calculated compressive resistances is smaller than 12%. This means, if the variation of the calculated resistances is too high in a group of tests, the group has to be divided into subgroups or has to be regrouped if possible. Therefore, the benefit of a larger number of tests and a corresponding smaller correlation factor could be lost, if the variation in ground parameters is too high. This clause introduces some choices left to the designer regarding the regrouping, but this is hardly new, as the grouping itself has not been regulated by the code.

Second, an interesting new remark now reveals, that the correlation factors correspond to a test grid with a reference spacing (d_{ref}) of 30 m. A second remark states, that "Values of the correlation factors can be adjusted for the test profiles according to":

$$\xi'_{mean} = 1 + \frac{d_{avg}}{d_{ref}}(\xi_{mean} - 1) \tag{4}$$

$$\xi'_{min} = 1 + \frac{d_{avg}}{d_{ref}}(\xi_{min} - 1) \tag{5}$$

This remark is intended to account for the beneficial effect of a test grid with a spacing smaller than 30 m, which is clear and understandable. The benefit can be observed on Figure 3.

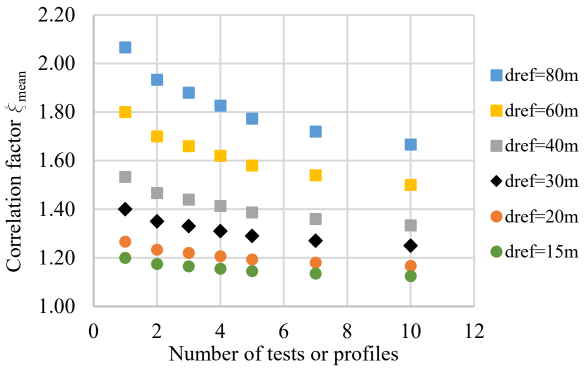


Figure 3. Effect of number of tests on the correlation factor ξ_{mean} for the Model Pile Method

However, the question arises, whether Equations 4 and 5 *should* be used if the test grid is larger than 30 m. The second-generation Eurocodes are quite clear about verbal forms and state that the verb "can" expresses possibility and capability. The Author's opinion is that if Equations 4 and 5 are used for accounting for a test grid with a spacing larger than 30 m, the increase in the correlation factors lead to a – probably not intended – significant reduction in the calculated R_{rep} resistances. This is highlighted in Figure 4.

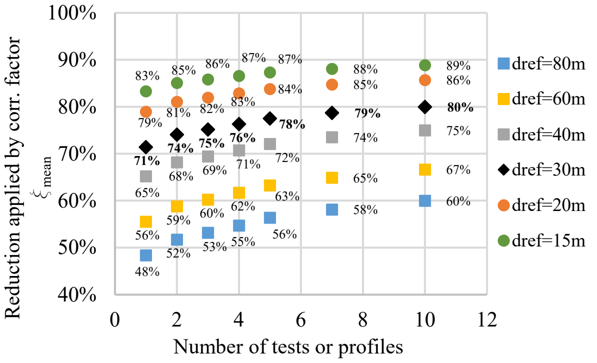


Figure 4. Reduction applied by the correlation factor ξ_{mean} for the Model Pile Method

Another interesting clause (FprEN1997-3:2024.TC250 (E) 6.6.2.4.2 (4)) states, that: "If the design is governed by $R_{calc,min}/\xi_{min}$ then at least one of the following conditions shall be met:

- the number of profiles per set is at least 5; and
- the coefficient of variation is determined and its value is smaller than 30%."

This means, that if the design is governed by a single CPT profile in the set which shows significantly worse soil conditions than the others in the group, the grouping may only remain, if the number of profiles is at least 5 or if the coefficient of variation is smaller than 30%. In other words, in the case of groups containing tests fewer than 5, the necessity of regrouping or the need of further tests only arises if the coefficient of variation is larger than 30%.

4 CASE STUDY

4.1 *Automated calculation*

For the determination of pile axial compressive resistance, a spreadsheet has been developed, which is capable of calculating based on 12 CPTs automatically given the pile geometry (top level, base level, diameter). The aim was to be able to switch on/off different CPTs and assess the effect of grouping and correlation factors easily.

The calculation is performed on filtered q_c data, whereby the weighted average of measured values (ten before, twenty after the current value) are taken if the current value is higher than the weighted average. This method was applied by (Szepesházi 2014) when calibrating his CPT based calculation method to pile load test results. Other authors mention other filtering techniques; these are also discussed in (Szepesházi 2014). Shaft resistance is than calculated based on each 10 cm averaged q_c values. Base resistance is calculated according to soil type (coarse grained or fine-grained), which is determined by the average SBTn index around the base level (1.5D above and 3D below base). Although the calculations are automated, the engineering work is indispensable while interpreting the results and making the final design decisions:

- is base in coarse-grained or fine-grained soil,
- grouping of CPT tests,

- which pile base levels are acceptable considering layer boundaries, boring technology and engineering judgement.

4.2 *Project description, layout, structures*

The case study uses the data from a large green field investment project in eastern Hungary. The development area will be built in several phases and cover an area of 1100 m by 1050 m. The soil investigation program consisted of a total of 149 CPTs and 107 drillings as well as MASW measurements made in sections with a total length of 2300 m, revealing the subsoil to an average depth of 40 m. The pile design was initially based on calculations with the use of CPT data and later they were supplemented by 4 compressive and a single tensile static pile load test. The investment consisted of several large industrial halls, roads, utilities and ancillary structures.

For the sake of clarity, in this case study, a hypothetical industrial hall is considered, and the analysis of pile foundation design is presented. The distance between each frame (axis) of the hall is 6.25 m, and the hall consists of 16 rasters (Figure 5.). The span is 25.0 m. Under each column a simplified load of F_d=7.5 MN is transferred to the pile caps, which must be supported by piles, the piling technology is CFA.

Two possible arrangements were investigated. First a pile cap with 2 by 3 piles was investigated with D=60 cm piles. Second, a pile cap with 2 by 2 piles with a diameter of D=80 cm was considered. The distance between the piles is 2.5 times the diameter. This means that in the case of 60 cm diameter piles the size of the pile cap is 2.3 x 3.8 x 0.6 m, in the case of 80 cm diameter piles it is 3.0 x 3.0 x 0.8 m. A total of 32 pile caps will be manufactured for the structure.

4.3 *Geotechnical investigation program*

The case study covers a small area within the site where a truss-structured hall is being built. This means that 10 CPTs were used for the example with a depth of 25 and 30 m. In the first preliminary phase of the design, we assumed an initial investigation program with 6 CPTs at the corner points of the building and at the midpoint of its longer side. Then a second investigation phase consisting of 4 more CPTs along the longer side of the structure was assumed. Thus, the tests are arranged in 2 rows and 5 columns, at a uniform distance of 25 m from each other.

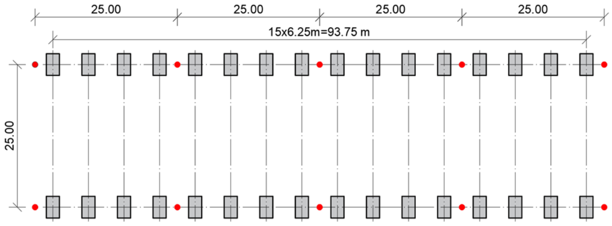


Figure 5. Simplified layout of pile caps (grey) and CPTs (red)

4.4 *Soil stratification*

Based on the investigations the following soil stratification was identified. The ground level varied between 103.9 and 105.0 m above Baltic Sea level (m aBSl). On the surface, there is an organic layer varying in thickness between 0.5 and 1.0 m. This is followed by 8-12 m of typically low plasticity clay and silty clay layers, with a cone resistance of q_c~1-2 MPa. The tests then indicated granular soils, silty sand and sand soils, with an average cone resistance of 15-20 MPa. This layer is 7-8 m thick. It is important to note that the layer is disrupted by several thin, low plasticity clay and silt layers with 0.5-1 m thickness and a q_c value of only 1-2 MPa. Underneath the granular layers, medium plasticity clays with more favorable resistance values were found down to the bottom of the tests. The q_c values measured in this layer reached 3-5 MPa. The observed stratification in the CPTs is consistent with the descriptions in geological literature and the borehole logs. The subsoil of the area is composed of Quaternary soils transported by wind and river sediments.

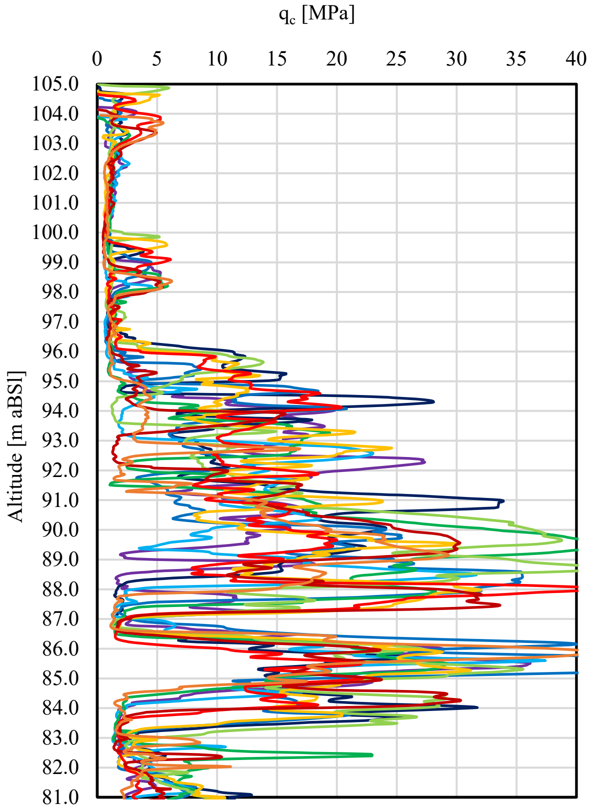


Figure 6. Tip resistance q_c of the ten CPT tests

5 PILE DESIGN

5.1 *Initial conditions*

The top level of the pile was set at 103.5 m aBsl. For the purposes of this study the calculations were performed for pile lengths between 12.0 and 20.0 m, with increments of 20 cm-s. In general, it is not necessary to calculate such a large number of pile lengths; it is more important that the pile base is embedded in a homogeneous layer with good bearing capacity and to avoid setting a pile base too close to a layer boundary between a granular and a cohesive soil layer. Our aim with the calculations was to closely monitor the variation coefficient (CoV) and the cases where $R_{calc,min}$ governs the final design value.

The calculations were performed with the Model Pile Method (with a model factor of $\gamma_{Rd,pile}$=1.1). According to the Hungarian National Annex, the partial safety factors for CFA technology are γ_{Rb}=1.20, γ_{Rs}=1.10, $\gamma_{R,st}$=1.15 in the first-generation Eurocodes and we assume that they will remain the same in the second generation.

The $R_{c,cal}$ value was calculated based on each CPT test, pile length and diameter according to Szepesházi's method as presented in (Szepesházi 2014) which is a slightly modified version of the method suggested in the Annex of Eurocode 7-3. This method is commonly used in Hungarian practice and was validated by static pile load tests.

Then, the design values were calculated based on EC7 first generation and also on second-generation regulations.

It was assumed that the pile cap evenly distributes the 7.5 MN load to the 60 cm diameter piles (F_{cd}=1.25 MN/pile) and the 80 cm diameter piles (F_{cd}=1.88 MN/pile).

Using the $R_{c,cal,i}$ values, the design value of the single pile axial resistance for each pile geometry was determined for each pile length.

The calculations were performed for different cases, to assess the effect of investigation numbers, the new correlation factors in the 2nd generation and different groupings of the CPT tests. For all cases the required pile length was determined and concrete usage (pile+pile cap) was assessed.

5.2 *Calculation results*

First, using the results of the 6 CPTs made for the preliminary design phase, the calculation was performed considering the hall area as a single design unit (Case 1) and 60 cm diameter piles in a 2 by 3 pile cap. In this case, the correlation factors are ξ_{mean}=1.28 and ξ_{min}=1.13. The calculation was then repeated, but this time taking into account the results of 4 additional CPTs completed in the detailed design phase, and thus reducing the correlation factors to ξ_{mean}=1.25 and ξ_{min}=1.08 (Case 2). As before, the hall area was considered as a single design unit.

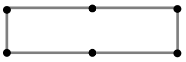
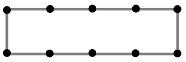
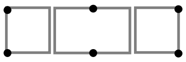
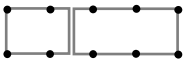
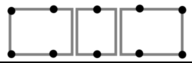
With the decrease in the correlation factors, both for the smaller and larger pile diameters, a higher axial compressive resistance, and thus a shorter pile length could be determined. For the purpose of comparability, the amount of concrete required for their construction was also determined. Thus, when applying the EC7 first generation, increasing the number of tests made it possible to slightly reduce the pile length. The result of the calculations is shown in Table 1. From a practical point of view, the cost of preparing four CPTs with a minimum length of 25 m should be compared with the amount of concrete that can be saved. Of course, the total number of piles required in the project must also be considered.

Table 1. Calculation results

Case	Lay-out*	EC7 gen.	Pile group	Pile dia. [cm]	Required pile length [m]	Concrete usage [m^3]
1	1	1st	2 x 3	60	17.2	1102
2	2	1st	2 x 3	60	17.0	1091
3	1	1st	2 x 2	80	17.2	1337
4	2	1st	2 x 2	80	17.0	1324
5	1	2nd	2 x 3	60	17.2	1102
6	2	2nd	2 x 3	60	17.0	1091
7	3	2nd	2 x 3	60	17.0-19.8	1167
8	4	2nd	2 x 3	60	16.8-17.2	1093
9	5	2nd	2 x 3	60	16.8-19.2	1112

*see Table 2.

Table 2. Grouping of CPTs for calculation cases

Layout	Number of CPTs	Zone arrangement
1	6	
2	10	
3	6 (2-2-2)	
4	10 (4-6)	
5	10 (4-2-4)	

Cases 3 and 4 repeated Cases 1 and 2, but with 80 cm diameter piles in a 2 by 2 pile cap. It is clear that in this case it is not worth designing the larger diameter piles because it gives more concrete usage. This was true in all further cases, so further results of 80 cm piles are not shown in the Table.

Cases 5 and 6 repeated Case 1 and 2 with the second-generation codes. Calculations show that the same total lengths of piles and amount of concrete is sufficient as using the first generation. It should be noted that in many cases, the $R_{calc,min}/\xi_{min}$ values were used to determine the design value in the second-generation calculations. Therefore, based on the second point of clause (4) of Chapter 6.6.2.1, the calculation is acceptable if the variation coefficient is less than 30%.

The results of Case 2 and 6 are compared in Figure 7. Tip resistances from the CPTs are shown with grey, calculated axial resistances are shown with colors. It can be observed that almost the same results were calculated for Case 2 and 6, hence the reduction of the correlation factors due to more CPT tests leads only to a slight increase in the bearing capacity with these pile geometries.

The correlation factors in the second-generation Eurocodes when considering a testing grid (d_{avg}) denser than 30 m (Case 6) are slightly lower than in the first generation. The average distance is exactly 25.0 m, which means it is allowed to reduce ξ_{mean}=1.25 to ξ'_{mean}=1.21 and ξ_{min}=1.08 to ξ'_{min}=1.07. This only brings a slight increase in axial resistance.

With the axial resistance calculated every 20 cm it is well visible, that it increases with depth from 90.5 to 86.0 m as the pile shaft gets longer, but also the significant contribution of a good base resistance in the granular layer around 86.1 can be observed clearly. It is also noteworthy that it is not advisable to choose a pile base directly below 86.1 m, as a longer pile would have smaller axial resistance. Such observations can be made based on detailed results of an automated calculation, so the benefit of automation aiding the engineer's decision is clear. However, a fully automated calculation might result in a pile geometry that is contrary to economical and engineering aspects.

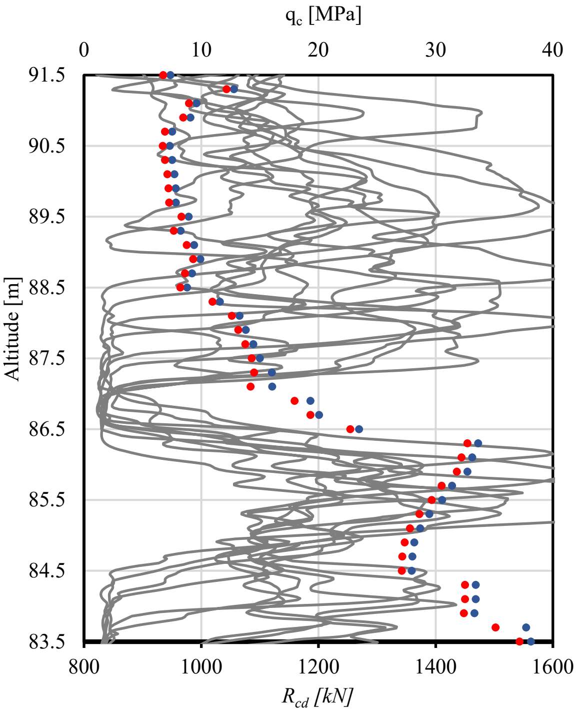


Figure 7. q_c values (grey) and calculated pile resistances (Case 2 in red, Case 6 in blue)

The effect of grouping CPTs into separate design units has also been investigated. The second generation requires that the variation coefficient of the $R_{c,cal}$ values be assessed and if $R_{calc,mean}$ governs the design, CoV must be lower than 12%. Keeping this in mind, different groups have been investigated. Calculations were performed using 6 and 10 CPTs. The investigated CPT groups are shown in Table 2.

When creating a subgroup, the calculated $R_{c,cal}$ values were checked, and the subgroups were formed based on engineering judgement. The CPTs were clustered using curves drawn from $R_{c,cal,i}$ values calculated at certain depths. Figure 8. shows a typical result. It should be noted, that the automated calculation helps once again in a more efficient grouping, as resistance values at a certain depth can be clustered conveniently, contrary to the traditional grouping approach, where only the CPT measurement data and their similarity was used for grouping. It is worth observing in Figure 8. that the optimal grouping is highly depending on the pile geometry also, not only the CPT data. This is evident when comparing the variation in resistances at a level of 90.5 m vs. at a level of 87.0 m.

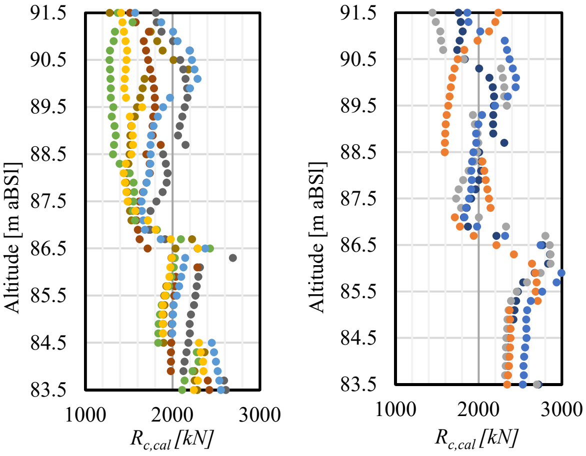


Figure 8. Grouping based on $R_{c,cal}$ values (Layout 4)

In the case where only 6 CPTs were available, 3 subgroups were formed (each containing 2 tests). In cases where the calculation was based on 10 CPTs, three zone arrangements were developed. In these layouts 2 to 6 CPT were placed in each subgroup (Table 2.).

In Case 7, the $R_{c,cal}$ values of the two middle CPTs in the three subgroups show the lowest values. This is also reflected in the calculation results: longer piles are required in the middle zone than on the edges. The amount of concrete required is higher than in the reference calculation. The result is a grouping that takes into account the variability of soil stratigraphy more accurately but requires more concrete, and is ultimately uneconomical.

In Case 8, a subgroup containing 4 CPTs on the left side and 6 CPTs on the right side was formed. The axial resistance is similar in both groups, but shorter piles were required in the group containing four CPTs. As before, changes in soil stratification can be followed better with this grouping. In this case, this only leads to a slight increase in the amount of concrete required.

Finally, by creating another group (Case 9), it was possible to separate the weaker middle zone. As a result, significantly longer piles were required in the middle. This is also reflected in the concrete quantities, but it should be noted that the longer piles only need to be used in a smaller area where there are only 8 pile caps.

In conclusion, based on this analysis, the correlation factor system benefits the execution of more CPTs, however, the achieved very slight increase in resistance means, that more CPTs do not automatically allow pile length reduction.

6 CONCLUSIONS

The second-generation Eurocode 7 standards refine the existing framework for pile design and bring several new aspects into design practice, concerning among others pile group design, piled raft foundation design and actions on piles due to ground displacements such as downdrag and heave.

In this paper we have shown the flow of geotechnical design in the new generation Eurocodes, giving emphasis to single pile axial compressive resistance.

The method for designing single piles based on CPT tests have been refined in the new generation Eurocodes. First, the Table of correlation factors have been amended with requirements connected to variation of calculated resistance values. This has an effect on grouping CPTs into design units within the Model Pile Method. Second, it is now emphasized, that the given correlation factors correspond to a grid of investigations with a reference distance of 30 m and can be adjusted to other grid distances. It is the Author's opinion that the adjustment to a denser grid is useful and beneficial, however the adjustment to a grid distance larger than 30 m is not advisable as this would lead to a probably undesirable reduction in the R_{rep} resistances.

A case study has been presented, which focused on the pile design of an idealized industrial building to showcase the changes due to the new requirements based on real project data. The benefits of an automated calculation of pile resistance based on CPT measurement data have been highlighted, among which the most important are:

- the economical design achievable by finding optimal pile base levels based on a large number of calculated resistances
- and optimal grouping of CPTs into design units, thus separating weak zones in the subsoil over a larger development area.

Automation is a powerful tool to enhance design and to find the most optimal solution, however engineering judgement and critical oversight is elementary in its application.

7 REFERENCES

Eurocode 7: Geotechnikai tervezés. 1. rész: *Általános szabályok*. MSZ EN 1997-1:2006 in Hungarian

Eurocode 7: Geotechnikai tervezés. 2. rész: *Tervezés laboratóriumi vizsgálatok alapján*. MSZ EN 1997-2:2008 in Hungarian

Eurocode 7: Geotechnical design Part 1: *General rules*. FprEN 1997-1 FV draft send to TC250, 2023.08.16

Eurocode 7: Geotechnical design Part 2: *Ground properties*. FprEN 1997-2 FV draft send to TC250, 2023.08.16

Eurocode 7: Geotechnical design Part 3: *Geotechnical structures*. 1997-3 FV draft send to TC250, 2023.08.16

European Commission: Joint Research Centre, *Determination of representative values from derived values for verification with limit states with EN 1997,* PO of the EU, Luxembourg, 2025, https://data.europa.eu/doi/10.2760/0980105, JRC141453.

European Commission: Joint Research Centre, CEN TC250 SC7 TG B2: JRC Technical Report – *Design examples using 2nd generation Eurocode 7*, 2024 October, Working Draft p. 40-74.,

Moormann, Ch.: *The second generation of Eurocode 7 – A modern basis for the design of piled foundations and ground improvements*. Int. Conf. on Deep Found. and Ground Improv., DFI-EFFC 2025, May 21-23, 2025, Bruges, Belgium.

Moormann, Ch.: Burlon, S.: *Eurocode 7 – second generation – piled foundations*. Proc. of the 18th ECSMGE, Lisbon, 2024, S. 1840-1845, ISBN 978-1-032-54816-6.

Szepesházi, R.: *Pile Design Based on CPT According to the Requirements of Eurocode 7*, Geosciences and Engineering, Vol. 3, No. 5 (2014) pp 59-69.