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EC 7: Characteristic Values for Geotechnical Parameters

EC 7: Valeurs caractéristiques des paramètres géotechniques

EC 7: Charakteristische Werte geotechnischer Parameter

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SUMMARY

Determining characteristic values for geotechnical parameters is an essential, but difficult task. It cannot be simply the result of a statistical analysis. It must take account of the scatter, but also of the geological context and the mode of interaction between the structure and the ground which is considered.

RESUME

La détermination des valeurs caractéristiques des paramètres géotechniques est une tâche essentielle, mais délicate. Elle ne peut être simplement le résultat d'une analyse statistique. Elle doit prendre en compte la dispersion, mais aussi le contexte géologique et le mode d'interaction entre l'ouvrage et le terrain considéré.

ZUSAMMENFASSUNG

Die Bestimmung von charakteristischen Werten geotechnischer Parameter ist eine grundlegende aber auch schwierige Aufgabe. Sie kann nicht einfach das Ergebnis einer statistischen Analyse sein. Es müssen sowohl die Streuung als auch der geologische Zusammenhang und die Art der Wechselwirkung zwischen Boden und Bauwerk berücksichtigt werden.

1. DEFINITION AND ROLE OF CHARACTERISTIC VALUES.

1.1 Eurocode 1 "Basis of design"

The April 92 draft [1] gives the following definitions:
"The material properties and their statistical variation should generally be obtained from tests on appropriate test specimens. The tests should be based on random samples which are representative with regard to the population under consideration.
A material property is represented by its characteristic value, f_k, which in general corresponds to an a priori specified fractile of the assumed statiscal distribution of the particular property in the supply produced within the scope of the relevant material standard."

The role of the characteristic values is to be a basis for the design values to be used in the verification of limit states. A material factor γ_m is used to reduce the characteristic value:
- in serviceability limit states, $\gamma_m = 1$.
- in ultimate limit states, γ_m is usually larger than 1 .

Thus, it is important to notice that the characteristic values are the design values in the verification of serviceability limit states, i.e. they must be somewhat conservative.

1.2 Eurocode 7 "Geotechnical design"

In the November 1989 draft [2], the application of the concept of characteristic value to soils or rocks is dealt with in paragraph 2.2.5 "material properties" of chapter 2 "Basis of design", clauses 2 to 4. With the same role in mind as in Eurocode 1, the determination of characteristic values has to be adapted to the particular situation of soils and rocks, which is quite different from the situation of manufactured materials such as steel and concrete.

Clause 3 indicates that *"the assessment shall take account of geological and other background information, such as relevant data from previous projects, together with the results of laboratory and field measurements."*
Clause 4 gives an indication of the degree of conservatism which should be attached to a characteristic value:
"Characteristic values shall be selected with the intention that the probability of a more unfavourable value governing the occurrence of a limit state is not greater than 5%."

But in the 'application rule' of this clause 4, the difficulty of using statistics with soils or rocks is pointed out:
"It might sometimes be helpful to use statiscal methods. However, it is emphasized that this will rarely lead directly to characteristic values since these depend on an assessment of the field situation. The choice of characteristic values is not dependent on the severity of the limit state under consideration. However, the choice is often dependent

on the mechanism or mode of deformation being considered."

During the consultations on the present draft of Eurocode 7, concern has been expressed about this definition of the characteristic value by the 5% risk and its possible legal implications. The drafting group has maintained the present text with two basic ideas in mind:
1) it is necessary to give an explicit definition of the characteristic value for soils and rocks, and therefore it is necessary to specify the fractile (or risk) which is mentionned in the general definition of Eurocode 1.
2) this statistical reference is given as a goal, not as a requirement for application, since statistical methods are rarely applicable in geotechnics.

The peculiarities, and difficulties, in assessing characteristic values for soils and rocks are examined below, with two main aspects being considered: 1) the soil or rock variability and the geological context, 2) the mechanism of interaction.

2. VARIABILITY AND GEOLOGICAL CONTEXT

2.1 Identifying homogeneous zones

In a statistical analysis, it is necessary to identify an homogeneous population before any attempt to determine its distribution law and to quantify the parameters of this distribution law.

This first task corresponds in geotechnical engineering to one of the main goals of the ground survey, which is identifying the natures and the extents, both in the vertical and horizontal directions, of the various soils and rocks. This has to be considered on a large scale (geological layers or formations, geological accidents) as well as on a small scale (e.g. seams).

In general, much effort is devoted to the detection of possible weak zones, due to some geological, local accident, for instance a fossile, tributary river in a main valley or in a slope, or a fault in a bedrock, or a deeper weathered zone. Cheap, quick investigation tools (geophysical methods, penetration tests) are often used for this purpose, while sophisticated, mechanical tests, which are a direct measurement of strength or deformation modulus, are performed in a limited number.

2.2 Using the statistics for soils and rocks

Once the danger of a possible, unknown weak zone has been reasonably kept away, the geotechnical engineer has to deal with 'homogeneous' soil or rock zones for which he has to select 'characteristic' values of strength or deformation modulus. However the use of statistics will

be generally limited, because :
1) the number of measurements will not generally be sufficient.
2) the application of statistics to ground is still in a infantile stage.

It is now recognized that the usual Gaussian law cannot be simply applied to soils, as for manufactured materials. Instead, the spatial variations have to be investigated, and researchers have shown that, for sedimentary soils, the auto-correlation distances are different in the vertical and horizontal directions.

To counter-balance these two defects: limited number of data, difficulty of applying statistics, the geotechnical engineer may draw upon two other sources to arrive at reasonable characteristic values:
1) general correlations on soil or rock properties; in particular, he may then be able to use the results of the quick, simple tests performed during the survey to detect the weak zones.
2) comparable experience, i.e. the experience gained in other sites on similar soils or rocks.

3. MECHANISMS OF INTERACTION

The soil or rock behaviour is complex: for instance, the strength of soils may depend on the type of loading and on the size of the loading. This is true for soil tests as well as for the structures.

Hence the need for calibration of design methods used in geotechnical engineering.

This also affects the choice of the characteristic values. Examples are given in the application rule of clause 4 : because of the size effect, the variability in the soil strength will affect more the ultimate limit bearing capacity of an end-bearing pile than the one of a friction pile in the same soil. On the other hand, the soil strength will be reduced by pile installation to a larger degree for the friction than for the end-bearing. Another example is the case of a shear surface in a fissured soil or rock; the characteristic strength to be used might be different, depending on whether the shear surface is free to follow the fissures or is constrained to intersect the intact material.

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