EN 1997
Eurocode: Geotechnical design

Section 2: Basis of geotechnical design

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2 Basis of geotechnical design

2.1 Design requirements

2.2 Design situations

2.3 Durability

2.4 Geotechnical design by calculation

2.5 Design by prescriptive methods

2.6 Load tests

2.7 The Observational Method

2.8 The Geotechnical Design Report

Annex A + B

2.1 Design requirements

(1)P For each geotechnical design situation it shall be verified that no relevant limit state, as defined in EN 1990:2002, is exceeded.

(4) Limit states **should** be verified by one or a combination of the following:

- use of calculations as described in 2.4;
- adoption of prescriptive measures, as described in 2.5;
- experimental models and load tests, as described in 2.6;
- an observational method, as described in 2.7.

2.1 Design requirements
Geotechnical Categories

(8)P In order to establish minimum requirements

- for the extent and content of geotechnical investigations,
- calculations and
- construction control checks,

the complexity of each geotechnical design shall be identified together with the associated risks.

(10) To establish geotechnical design requirements, three Geotechnical Categories, 1, 2 and 3, **may** be introduced.

2.1 Design requirements
Geotechnical Categories

(14) Geotechnical **Category 1** should only include small and relatively simple structures:

- for which it is possible to ensure that the fundamental requirements will be satisfied on the basis of experience and qualitative geotechnical investigations;
- with negligible risk.

(9) For structures and earthworks of low geotechnical complexity and risk, such as defined above, **simplified design procedures** may be applied.

2.1 Design requirements
Geotechnical Categories

(17) **Geotechnical Category 2** should include conventional types of structure and foundation with no exceptional risk or difficult soil or loading conditions.

(18) Designs for structures in Geotechnical Category 2 should normally include quantitative geotechnical data and analysis to ensure that the fundamental requirements are satisfied.

(19) Routine procedures for field and laboratory testing and for design and execution may be used for Geotechnical Category 2 designs.

2.1 Design requirements
Geotechnical Categories

(20) **Geotechnical Category 3** should include structures or parts of structures, which fall outside the limits of Geotechnical Categories 1 and 2.

(21) Geotechnical Category 3 should normally include alternative provisions and rules to those in this standard.

NOTE Geotechnical Category 3 includes the **following examples**:

- very large or unusual structures;
- structures involving abnormal risks, or unusual or exceptionally difficult ground or loading conditions;
- structures in highly seismic areas;
- structures in areas of probable site instability or persistent ground movements that require separate investigation or special measures.

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2.2 Design Situations (EN 1997-1)

(1)P Both short-term and long-term design situations shall be considered.

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2 Basis of geotechnical design

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2.4 Geotechnical design by calculation

2.4.5.2 Characteristic values of geotechnical parameters

(1)P The selection of characteristic values for geotech-nical parameters shall be based on results and derived values from laboratory and field tests, complemented by well-established experience.

(2)P The characteristic value of a geotechnical parameter shall be selected as a cautious estimate of the value affecting the occurrence of the limit state.

2.4 Geotechnical design by calculation

2.4.5.2 Characteristic values of geotechnical parameters

4)P The selection of characteristic values for geotechnical parameters shall take account of the following:

- ...
- the type and number of samples;
- the extent of the zone of ground governing the behaviour of the geotechnical structure at the limit state being considered;
- the ability of the geotechnical structure to transfer loads from weak to strong zones in the ground. …..

2.4 Geotechnical design by calculation

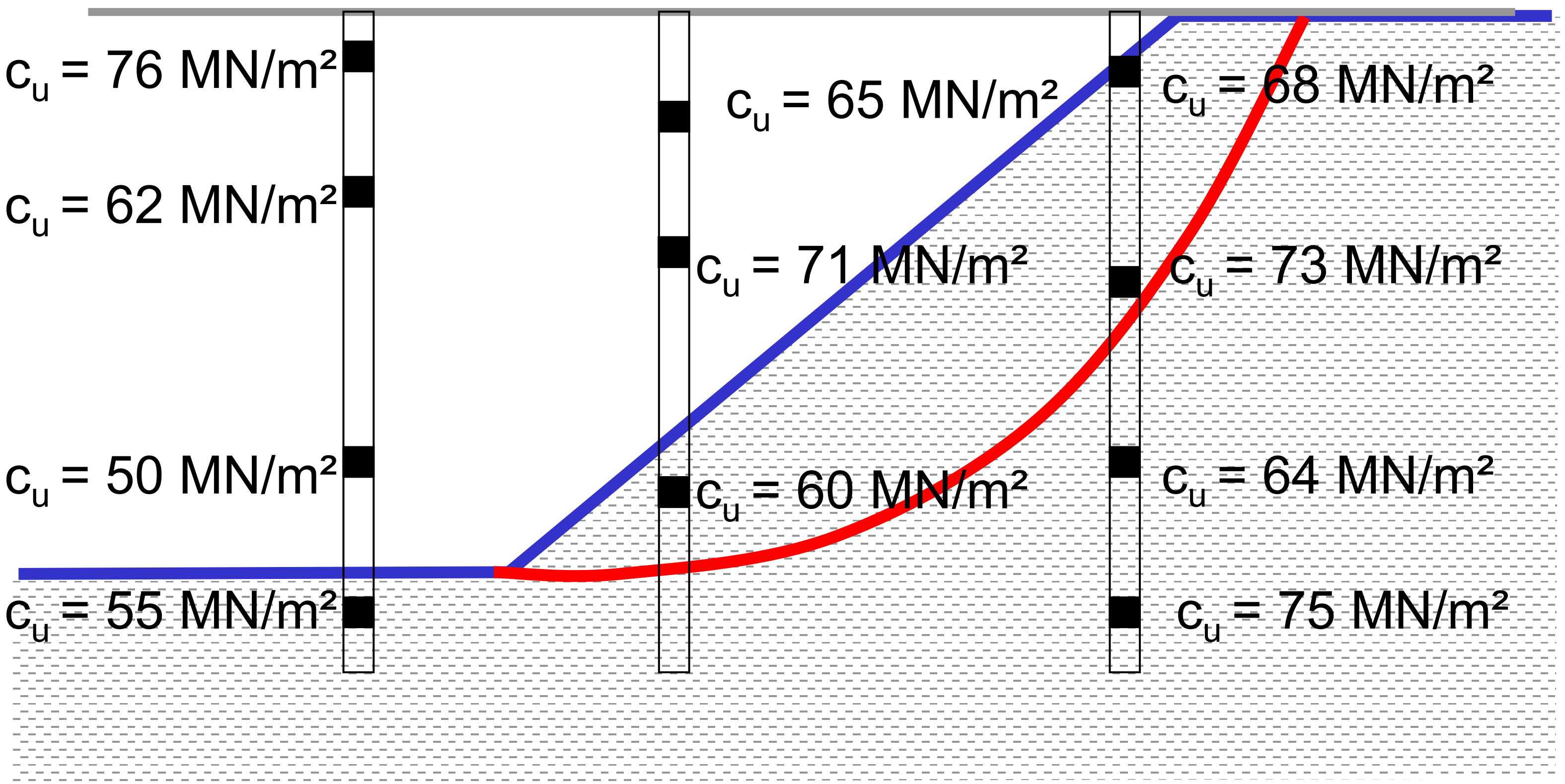
2.4.5.2 Characteristic values of geotechnical parameters

(10) If statistical methods are employed in the selection of characteristic values for ground properties, such methods should differentiate between local and regional sampling and should allow the use of a priori knowledge of comparable ground properties.

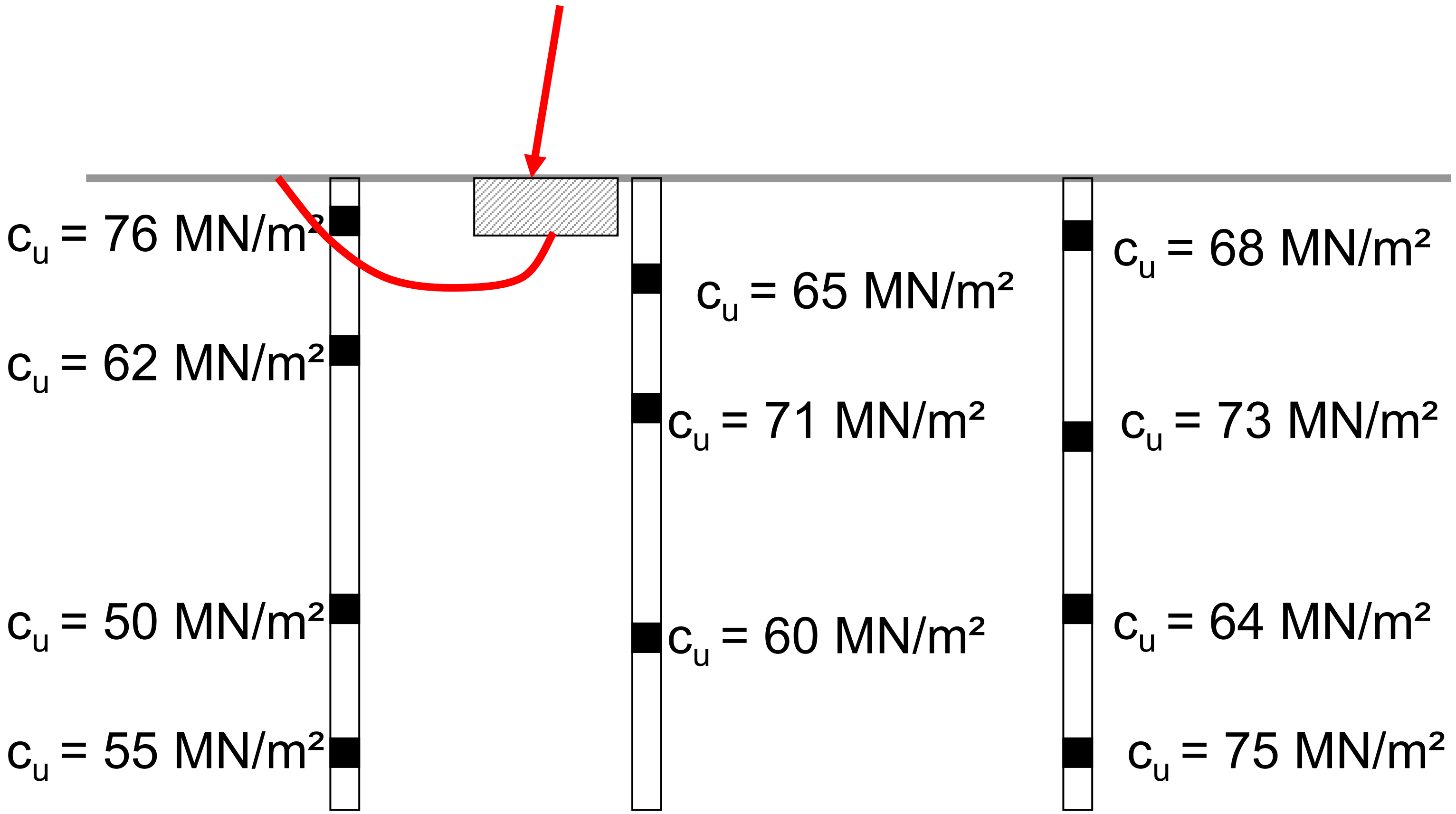
(11) If statistical methods are used, the characteristic value should be derived such that the calculated probability of a worse value governing the occurrence of the limit state under consideration is not greater than 5%.

NOTE In this respect, a cautious estimate of the mean value is a selection of the mean value of the limited set of geotechnical parameter values, with a confidence level of 95%; where local failure is concerned, a cautious estimate of the low value is a 5% fractile.

Selection of characteristic values: Slope failure in a cut



Selection of characteristic values:



2.4 Geotechnical design by calculation

2.4.5.2 Characteristic values of geotechnical parameters

Determination of the characteristic value X_k by statistical methods:

$$X_k = X_{mean} \, (1 - k_n \cdot V_x)$$

where

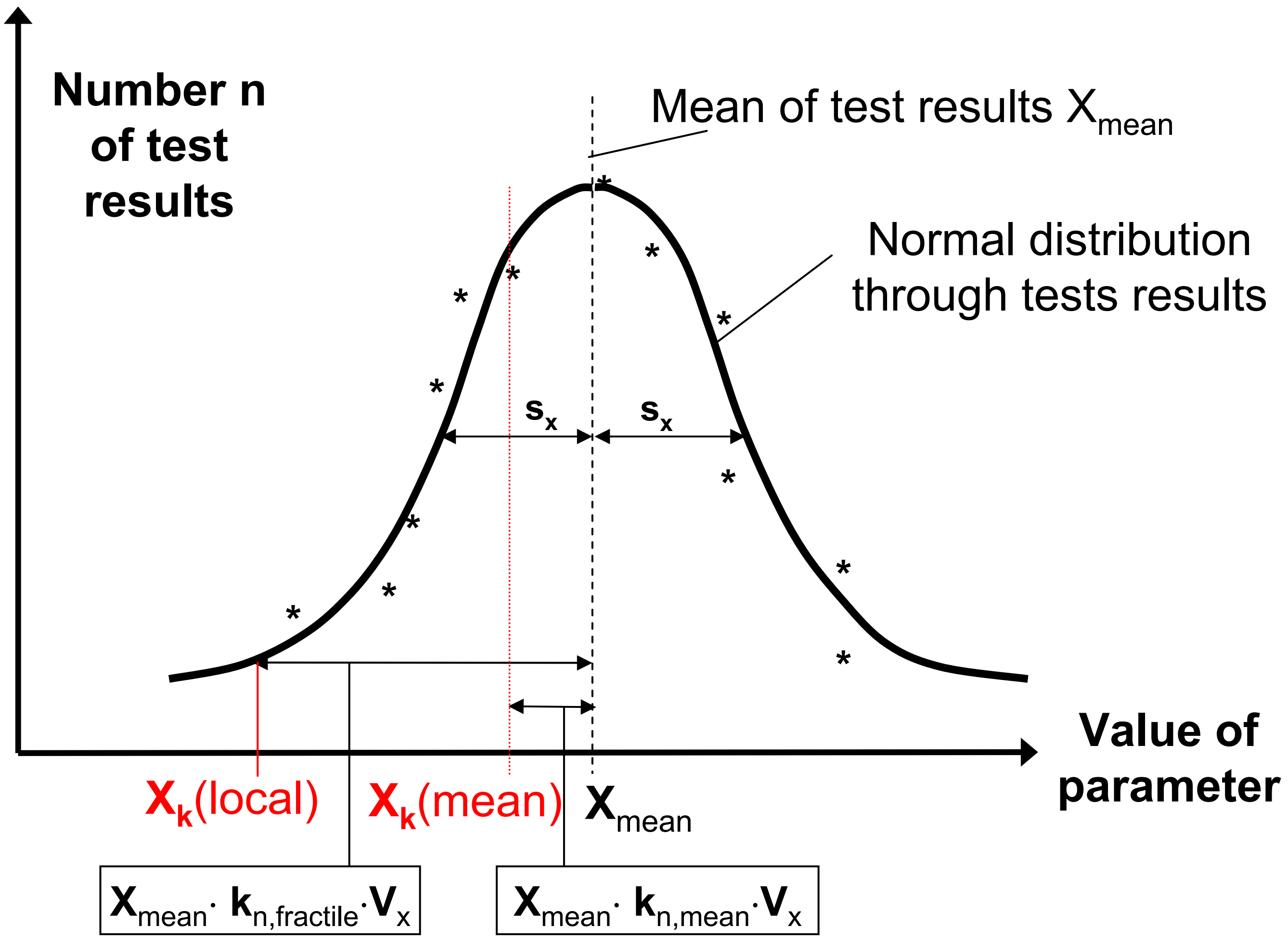
X_{mean} arithmetical mean value of the parameter values;

V_x the coefficient of variation

k_n statistical coefficient which depends on the number n of test results, the level of confidence and a priori knowledge about the coefficient of variation (case ”V_x unknown” or ”V_x known”).

2.4 Geotechnical design by calculation

2.4.5.2 Characteristic values of geotechnical parameters



2.4 Geotechnical design by calculation

2.4.5.2 Characteristic values of geotechnical parameters

Determination of characteristic values proposed by Schneider (1999):

$$X_k = X_{mean} - 0.5 \cdot s_x$$

2.4 Geotechnical design by calculation

2.4.5.2 Characteristic values of geotechnical parameters

Example: results of triaxial tests used for the selection of the characteristic values using statistical methods (V_x unknown)

Borehole / test Statistical result	c’ [kPa]	φ’ [°]	tan φ’ [-]
BH 1/1	3	31	0,601
BH 1/2	4	30	0,577
BH 2/1	1	35	0,700
BH 2/2	7	28	0,532
Mean value	$c'_{mean} = 3.75$		$(\tan \varphi')_{mean} = 0.603$
Standard deviation	$s_c = 2.50$		$s_\varphi = 0.071$
Coefficient of variation	$V_c = 0.667$		$V_{\tan\varphi} = 0.118$

2.4 Geotechnical design by calculation

2.4.5.2 Characteristic values of geotechnical parameters

Table: summary of the statistical evaluation of the example

Basis and method of statistical evaluation	Characteristic values of shear parameter	
	φ'_k [°]	c'_k [kPa]
φ' and c' of 4 tests for the case **"V_x unknown"**	27.5	0.8
φ' and c' of 4 tests for the case **"V_x known"**	29.0	2.5
Schneider (1999)	29.5	2.5

2.4 Geotechnical design by calculation

2.4.2 Actions

(1)P The **definition of actions** shall be taken from EN 1990:2002. The **values of actions** shall be taken from EN 1991, where relevant.

EN 1997-1:
1.5.2.1 **Geotechnical action**

Action transmitted to the structure by the ground, fill standing water or groundwater.

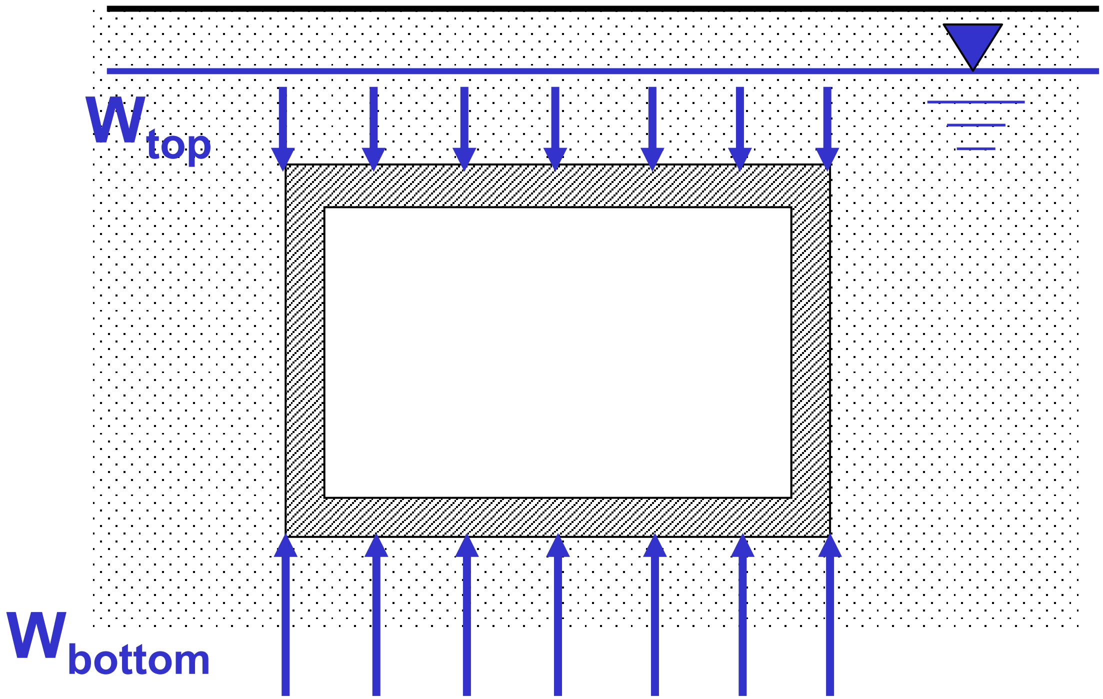
2.4 Geotechnical design by calculation

2.4.2 Actions

NOTE (to (9)P) Unfavourable (or destabilising) and favourable (or stabilising) permanent actions may in some situations be considered as coming from a single source. If they are considered so, a single partial factor may be applied to the sum of these actions or to the sum of their effects.

2.4 Geotechnical design by calculation

2.4.2 Actions



~~$W_d = W_{bottom} \cdot \gamma_{dst} - W_{top} \cdot \gamma_{stb}$~~

$$W_d = (W_{bottom} - W_{top}) \cdot \gamma_{dst}$$

2.4.6.1 Design values of actions

(2)P The design value of an action (F_d) shall either be assessed directly or shall be derived from representative values F_{rep} using the following equation:

$$F_d = \gamma_F \cdot F_{rep} \quad (2.1a)$$

with

$$F_{rep} = \psi \cdot F_k \quad (2.1b)$$

where γ_F is the partial factor on geotechnical actions or effects of geotechnical actions and ψ is a combination factor.

(3)P Appropriate values of ψ shall be taken from EN 1990:2002.

2.4.6.1 Design values of actions

(2)P The design value of an action (F_d) shall either be assessed directly or shall be derived from representative values F_{rep} using the following equation:

$$F_d = \gamma_F \cdot F_{rep} \qquad (2.1a)$$

with

$$F_{rep} = \psi \cdot F_k \qquad (2.1b)$$

where γ_F is the partial factor on geotechnical actions or effects of geotechnical actions and ψ is a combination factor.

(4)P The partial factor γ_F for persistent and transient situations defined in **Annex A** shall be used in equation (2.1a).

Annex A (normative) Partial factors

A.3.1 Partial factors on actions or the effects of actions

NOTE The values to be ascribed to γ_G and γ_Q for use in a country may be found in its National annex to EN 1990. The recommended values for buildings in EN 1990:2002 for the two sets *A1* and *A2* are given in Table A.3.

Table A.3: Partial factors on actions (γ_F) or the effects of actions (γ_E)

Action		Symbol	Set	
			A1	*A2*
Permanent	Unfavourable	γ_G	1,35	1,0
	Favourable		1,0	1,0
Variable	Unfavourable	γ_Q	1,5	1,3
	Favourable		0	0

2.4.6.2 Design values of geotechnical parameters

(1)P Design values of geotechnical parameters (X_d) shall either be derived from characteristic values using the following equation:

$$X_d = X_k / \gamma_M \qquad (2.2)$$

or shall be assessed directly.

(2)P The partial factor γ_M for persistent and transient situations defined in Annex A shall be used in equation (2.2).

Annex A (normative) Partial factors

Table A.4 - Partial factors for soil parameters (γ_M)

Soil parameter	Symbol	Set	
		M1	*M2*
Shearing resistance	$\gamma_{\varphi}{}^{1}$	1,0	1,25
Effective cohesion	γ_{c}	1,0	1,25
Undrained strength	γ_{cu}	1,0	1,4
Unconfined strength	γ_{qu}	1,0	1,4
Unit weight density	γ_{γ}	1,0	1,0

2.4.7 Ultimate limit states

2.4.7.1 General

(1)P Where relevant, it shall be verified that the following limit states are not exceeded:

- …………..
- failure or excessive deformation of the ground, in which the strength of soil or rock is significant in providing resistance (**GEO**);
- loss of equilibrium of the structure or the ground due to uplift by water pressure (buoyancy) or other vertical actions (**UPL**);
- hydraulic heave, internal erosion and piping in the ground caused by hydraulic gradients (**HYD**).

2.4.7.3 Verification of resistance for GEO and STR

(1)P When considering a limit state of rupture or excessive deformation of a structural element or section of the ground (**STR** and **GEO**), it shall be verified that:

$$\mathbf{E_d} \leq \mathbf{R_d} \qquad (2.5)$$

E_d : the design value of the effects of all the actions;
R_d : the design value of the corresponding resistance of the ground and/or structure.

Load and Resistance Factor Approach

$$E_d \leq R_d$$

$$E_k(\varphi'_k, c'_k) \cdot \gamma_E \leq R_k(\varphi'_k, c'_k) / \gamma_R$$

E_k:	characteristic value of the effect of action
γ_E:	partial factor for the effect of action or the action
R_k:	characteristic values of ground resistance
γ_R:	partial factor for the ground resistance
φ'_k, c'_k:	characteristic values of the shear parameter

Design values of shear parameter

$$\tan \varphi'_d = (\tan \varphi'_k) / \gamma_\varphi$$

$$c'_d = c'_k / \gamma_c$$

φ'_k, c'_k characteristic value of shear parameter

φ'_d, c'_d design values of the shear parameter

γ_φ partial factor for the angle of shearing resistance

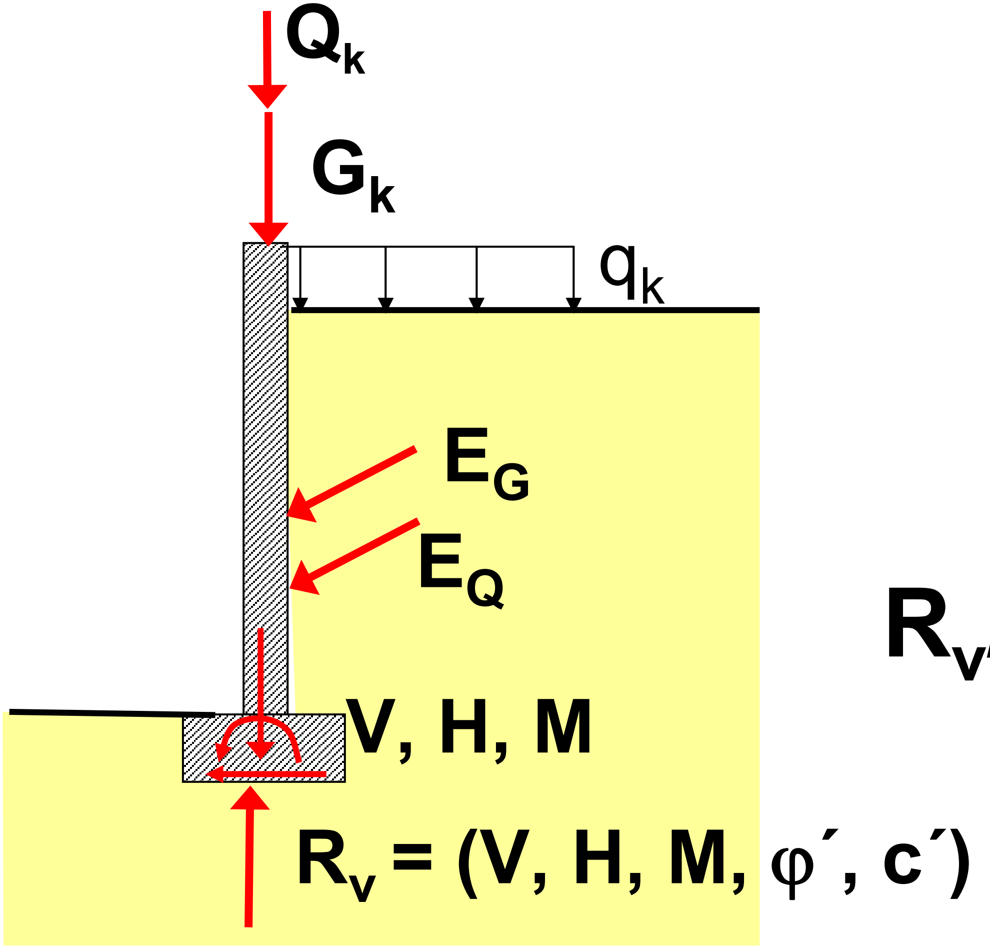
γ_c partial factor for the cohesion intercept

Material Factor Approach

$$E_d(\varphi'_d, c'_d) \leq R_d(\varphi'_d, c'_d)$$

E_d	design value of the effects of actions of the ground
R_d:	design value of the ground resistance
φ'_d	design value of the angle of shearing resistance
c'_d	design value of the cohesion intercept

Example for the three Design Approaches



$$R_v/V \geq \eta$$

2.4.7.3 Verification of resistance for GEO and STR

<table>
<tr><th rowspan="2" colspan="2">Design Approach</th><th colspan="2">Action or effects of actions</th><th rowspan="2">Resistance ground</th></tr>
<tr><th>structure</th><th>ground</th></tr>
<tr><td rowspan="2">1</td><td></td><td colspan="2"></td><td></td></tr>
<tr><td></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="2">2</td><td colspan="2"></td><td></td></tr>
<tr><td colspan="2">3</td><td></td><td colspan="2"></td></tr>
</table>

2.4.7.3 Verification of resistance for GEO and STR

Design Approach 1

<table>
<tr><th rowspan="2" colspan="2">Design Approach</th><th colspan="2">Action or effects of actions</th><th rowspan="2">Resistance ground</th></tr>
<tr><th>Structure</th><th>Ground</th></tr>
<tr><td rowspan="2">1</td><td>Comb. 1</td><td colspan="2">$\gamma_G = 1.35; \gamma_{G,inf} = 1.00; \gamma_Q = 1.50$</td><td>$\gamma_\varphi = \gamma_c = 1.0$</td></tr>
<tr><td>Comb. 2</td><td>$\gamma_G = 1.00; \gamma_Q = 1.30$</td><td colspan="2">$\gamma_\varphi = \gamma_c = 1.25$</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td><td></td></tr>
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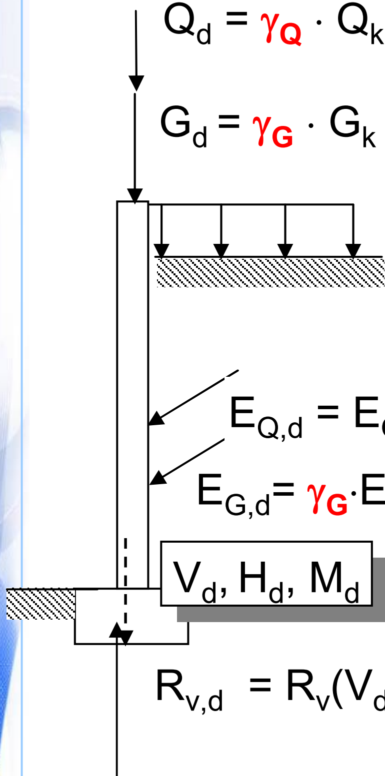
</table>

2.4.7.3 Verification of resistance for GEO and STR

Design Approach 1

Combination 1



$Q_d = \gamma_Q \cdot Q_k = \mathbf{1.50} \cdot Q_k$

$G_d = \gamma_G \cdot G_k = \mathbf{1.35} \cdot G_k$

$q_d = \gamma_Q \cdot q_k = \mathbf{1.50} \cdot q_k$

$\gamma_{\varphi'} = \gamma_c = 1.0$
$\varphi'_d = \varphi'_k, \; c'_d = c'_k$

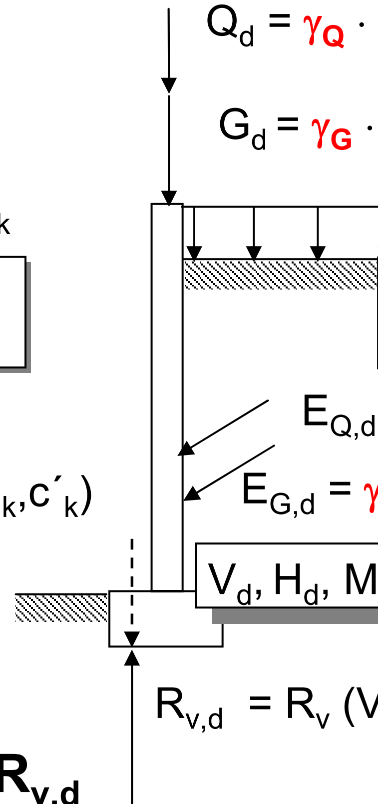
$E_{Q,d} = E_Q(\varphi'_d, c'_d, q_d)$

$E_{G,d} = \gamma_G \cdot E_G(\varphi'_d, c'_d) = \mathbf{1.35} \cdot E_G(\varphi'_k, c'_k)$

V_d, H_d, M_d

$R_{v,d} = R_v(V_d, H_d, M_d, \varphi'_d, c'_d)$

Combination 2



$Q_d = \gamma_Q \cdot Q_k = \mathbf{1.30} \cdot Q_k$

$G_d = \gamma_G \cdot G_k = \mathbf{1.00} \cdot G_k$

$q_d = \gamma_Q \cdot q_k = \mathbf{1.30} \cdot q_k$

$\tan\varphi'_d = \tan\varphi'_k / \gamma_{\varphi'} = \tan\varphi'_k / \mathbf{1.25}$
$c'_d = c'_k / \gamma_c = c'_k / \mathbf{1.25}$

$E_{Q,d} = E_Q(\varphi'_d, c'_d, q_d)$

$E_{G,d} = \gamma_G \cdot E_G(\varphi'_d, c'_d) = 1.00 \cdot E_G(\varphi'_d, c'_d)$

V_d, H_d, M_d

$R_{v,d} = R_v(V_d, H_d, M_d, \varphi'_d, c'_d)$

$$\mathbf{V_d \leq R_{v,d}}$$

2.4.7.3 Verification of resistance for GEO and STR

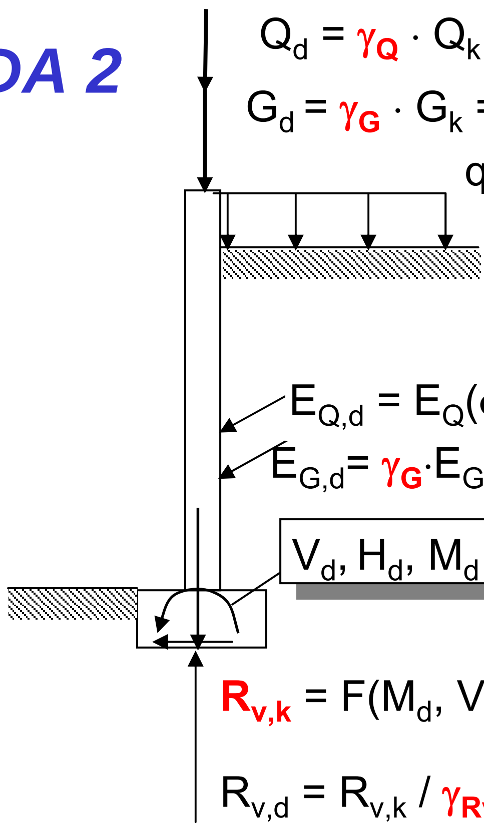
Design Approach 2

Design Approach		Action or effects of actions: Structure	Action or effects of actions: Ground	Resistance ground
1	Comb. 1	$\gamma_G = 1.35$; $\gamma_{G,inf} = 1.00$; $\gamma_Q = 1.50$		$\gamma_\varphi = \gamma_c = 1.0$
1	Comb. 2	$\gamma_G = 1.0$; $\gamma_Q = 1.30$	$\gamma_\varphi = \gamma_c = 1.25$	
2		$\gamma_G = 1.35$; $\gamma_{G,inf} = 1.00$; $\gamma_Q = 1.50$		$\gamma_{R;e} = \gamma_{R;v} = 1.40$ $\gamma_{R;h} = 1.10$

2.4.7.3 Verification of resistance for GEO and STR

Design Approach 2

DA 2



$Q_d = \gamma_Q \cdot Q_k = 1.50 \cdot Q_k$

$G_d = \gamma_G \cdot G_k = 1.35 \cdot G_k$

$q_d = \gamma_Q \cdot q_k = 1.50 \cdot q_k$

$\gamma_{\varphi'} = \gamma_c = 1.00$

$\varphi'_d = \varphi'_k, \; c'_d = c'_k$

$E_{Q,d} = E_Q(\varphi'_d, c'_d, q_d)$

$E_{G,d} = \gamma_G \cdot E_G(\varphi'_d, c'_d) = 1.35 \cdot E_G(\varphi'_k, c'_k)$

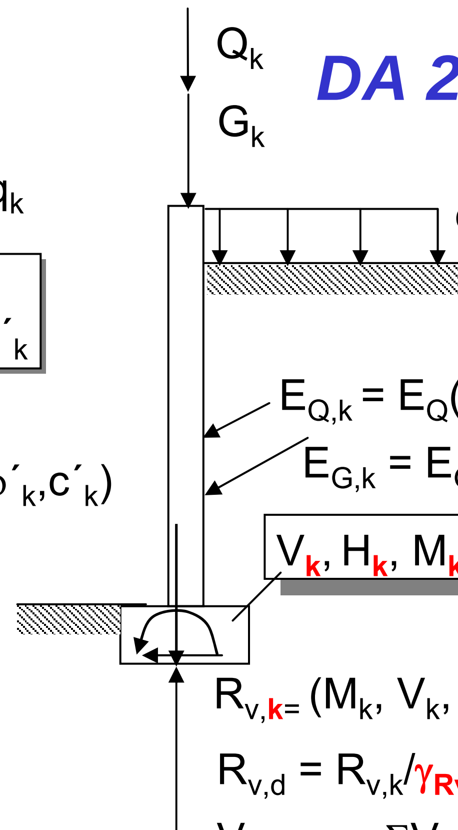
V_d, H_d, M_d

$R_{v,k} = F(M_d, V_d, H_d, \varphi'_d, c'_d)$

$R_{v,d} = R_{v,k} / \gamma_{Rv} = R_{v,k} / 1.40$

$V_d \le R_{v,d}$

DA 2*



Q_k

G_k

q_k

$\gamma_\varphi = \gamma_c = 1.0$

$\varphi'_d = \varphi'_k, \; c'_d = c'_k$

$E_{Q,k} = E_Q(\varphi'_k, c'_k, q_k)$

$E_{G,k} = E_G(\varphi'_k, c'_k)$

V_k, H_k, M_k

$R_{v,k} = (M_k, V_k, H_k, \varphi'_k, c'_k)$

$R_{v,d} = R_{v,k}/\gamma_{Rv} = R_{v,k}/1.40$

$V_d = \gamma_G \cdot \Sigma V_{G,k} + \gamma_Q \cdot \Sigma V_{Q,k}$

$V_d = 1.35 \cdot \Sigma V_{G,k} + 1.50 \cdot \Sigma V_{Q,k}$

2.4.7.3 Verification of resistance for GEO and STR

Design Approach 3

<table>
<tr><th rowspan="2" colspan="2">Design Approach</th><th colspan="2">Action or effects of actions</th><th rowspan="2">Resistance ground</th></tr>
<tr><th>Structure</th><th>Ground</th></tr>
<tr><td rowspan="2">1</td><td>Comb. 1</td><td colspan="2">γ_G = 1.35; $\gamma_{G,inf}$ = 1.00; γ_Q = 1.50</td><td>$\gamma_\varphi = \gamma_c$ = 1.0</td></tr>
<tr><td>Comb. 2</td><td>γ_G = 1.0; γ_Q = 1.30</td><td colspan="2">$\gamma_\varphi = \gamma_c$ = 1.25</td></tr>
<tr><td colspan="2">2</td><td colspan="2">γ_G = 1.35; $\gamma_{G,inf}$ = 1.00; γ_Q = 1.50</td><td>$\gamma_{R;e} = \gamma_{R;v}$ = 1.40
$\gamma_{R;h}$ = 1.10</td></tr>
<tr><td colspan="2">**3**</td><td>γ_G = 1.35; $\gamma_{G,inf}$ =1.00
γ_Q = 1.50</td><td colspan="2">$\gamma_\varphi = \gamma_c$ = 1.25</td></tr>
</table>

2.4.7.3 Verification of resistance for GEO and STR

Design Approach 3

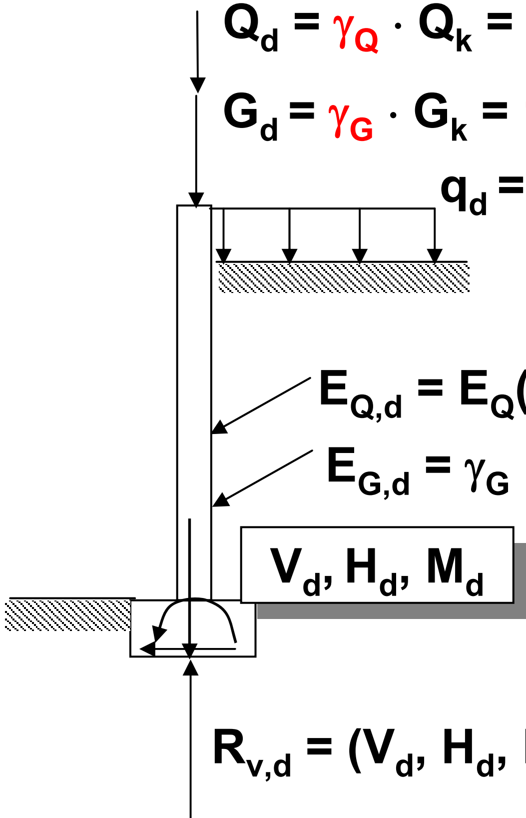
$$Q_d = \gamma_Q \cdot Q_k = 1.50 \cdot Q_k$$

$$G_d = \gamma_G \cdot G_k = 1.35 \cdot G_k$$

$$q_d = \gamma_Q \cdot q_k = 1.50 \cdot q_k$$

$$\tan \varphi'_d = \tan\varphi'_k / \gamma_{\varphi'} = \tan\varphi'_k / 1.25$$

$$c'_d = c'_k / \gamma_c = c'_k \,/\, 1.25$$



$$E_{Q,d} = E_Q(\varphi'_d, c'_d, q_d)$$

$$E_{G,d} = \gamma_G \cdot E_G(\varphi'_d, c'_d) = 1.00 \cdot E_G(\varphi'_d, c'_d)$$

$$R_{v,d} = (V_d, H_d, M_d, \varphi'_d, c'_d)$$

$$V_d \leq R_{v,d}$$

2.4.8 Serviceability limit states

(1)P Verification for serviceability limit states in the ground or in a structural section, element or connection, shall either require that:

$$\boldsymbol{E_d \leq C_d}, \qquad (2.10)$$

or be done through the method given in 2.4.8 (4).

E_d: effects of the actions e.g. deformations, differential settlements, vibrations etc.

C_d: limiting values

(2) Values of partial factors for serviceability limit states should normally be taken equal to 1,0.

(5)P …… This limiting value shall be agreed during the design of the supported structure

Annex H
(informative)
Limiting values of structural deformation and foundation movement

(2) The maximum acceptable relative rotations for open framed structures, infilled frames and load bearing or continuous brick walls are unlikely to be the same but are likely to range from about 1/2000 to about 1/300, to prevent the occurrence of a serviceability limit state in the structure. A maximum relative rotation of 1/500 is acceptable for many structures. The relative rotation likely to cause an ultimate limit state is about 1/150.

2 Basis of geotechnical design

2 Basis of geotechnical design

2.1 Design requirements

2.2 Design situations

2.3 Durability

2.4 Geotechnical design by calculation

2.5 Design by prescriptive methods

2.6 Load tests

2.7 The Observational Method

2.8 The Geotechnical Design Report

2.7 Observational method

(1) When prediction of geotechnical behaviour is difficult, it can be appropriate to apply the approach known as "the observational method", in which the design is reviewed during construction.

(2)P The following requirements shall be met before construction is started:

- **acceptable limits of behaviour** shall be established;
- the **range of possible behaviour** shall be assessed and
- it shall be shown that there is an **acceptable probability** that the actual behaviour will be within the acceptable limits;

2.7 Observational method

- a **plan of monitoring** shall be devised, which will reveal whether the actual behaviour lies within the acceptable limits. The monitoring shall make this clear at a sufficiently early stage, and with sufficiently short intervals to allow contingency actions to be undertaken successfully;
- the **response time** of the instruments and the procedures for analysing the results shall be sufficiently rapid in relation to the possible evolution of the system;
- a **plan of contingency actions** shall be devised, which may be adopted if the monitoring reveals behaviour outside acceptable limits.

2 Basis of geotechnical design

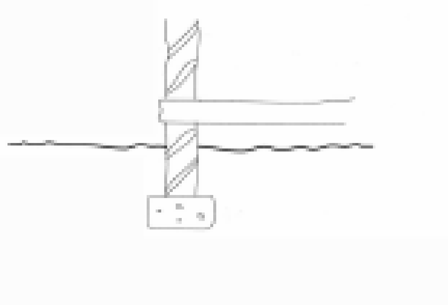
2.8 Geotechnical Design Report

(1)P The assumptions, data, methods of calculation and results of the verification of safety and serviceability shall be recorded in the Geotechnical Design Report.

(2) The level of detail of the Geotechnical Design Reports will vary greatly, depending on the type of design. For simple designs, a single sheet may be sufficient.

2.8 Geotechnical Design Report

<table>
<tr><td rowspan="4">Job Title
New start housing development

Structure Reference:
Strip foundations</td><td>Job No.</td><td>Sheet no of ………</td></tr>
<tr><td colspan="2">Made by: Date ……………</td></tr>
<tr><td colspan="2">Checked by: Date ……………</td></tr>
<tr><td colspan="2">Approved by: Date ……………</td></tr>
<tr><td>Report used:
Ground Investigation report (give ref. date)
Factual:
Bloggs Investigations Ltd report ABC/123 dated 21 Feb 95
Interpretation:
Ditto</td><td colspan="2" rowspan="2">Section throug
</td></tr>
<tr><td>Codes and standards used (level of acceptable risk)
Eurocode 7
Local building regs</td></tr>
<tr><td>Description of site surroundings:
Formerly agricultural land.
Gently sloping (4°)</td><td colspan="2">Assumed stratigraphy used in design with properties:
Topsoil and very weathered glacial till up to 1 m thick, overlying firm to stiff glacial till (c_u 60 kPa on pocket penetrometer).</td></tr>
<tr><td>Calculations (or index calculations)
Characteristic load 60 kN/m.
Local experience plus Local Building Regulations (ref ……..) indicates working bearing pressure of 100 kPa acceptable. Therefore adopt footings 0.6 m wide, minimum depth 0.5 m (Building Regs) but depth varies to reach c_u 60 kPa – test on site.</td><td colspan="2">Information to be verified during construction.
Notes on maintenance and monitoring.
Concrete cas on un-softened glacial till with c_u 60 kPa (pocket penetrometer)</td></tr>
</table>

Summary

Section 2: *Basis of geotechnical design*:

- introduces Geotechnical Categories as options,
- describes geotechnical design situations,
- gives guidance to the selection of characteristic values of ground parameter,
- defines geotechnical ultimate limit states,
- defines three Design Approaches as options and
- introduces the Observational Method

Thank you

2.3 Durability

(1)P At the geotechnical design stage, the significance of environmental conditions shall be assessed in relation to durability and to enable provisions to be made for the protection or adequate resistance of the materials.

2.4 Geotechnical design by calculation

- characteristic values
  - geotechnical parameter
  - actions
- design values
- ultimate limit states
  - geotechnical limit states
  - design approaches DA1, DA2 and DA 3
- serviceability limit states

Annex A (normative)
Partial and correlation factors for ultimate limit states and recommended values

A.3.1 Partial factors on actions (γ_F) or the effects of actions (γ_E)

(1)P For the verification of structural (STR) and geotechnical (GEO) limit states set *A1* or set *A2* of the following partial factors on actions (γ_F) or the effects of actions (γ_E) shall be applied:

γ_G on permanent unfavourable or favourable actions;

γ_Q on variable unfavourable or favourable actions.

2.4.7 Ultimate limit states

2.4.7.1 General

(1)P Where relevant, it shall be verified that the following limit states are not exceeded:

- loss of equilibrium of the structure or the ground, considered as a rigid body, in which the strengths of structural materials and the ground are insignificant in providing resistance (**EQU**);
- internal failure or excessive deformation of the structure or structural elements, including e.g. footings, piles or basement walls, in which the strength of structural materials is significant in providing resistance (**STR**);

2.4.8 Serviceability limit states

(1)P Verification for serviceability limit states in the ground or in a structural section, element or connection, shall either require that:

$$\boldsymbol{E_{d} \leq C_{d}}, \qquad (2.10)$$

or be done through the method given in 2.4.8 (4).

E_d: effects of the actions e.g. deformations, differential settlements, vibrations etc.

C_d: limiting values

(2) Values of partial factors for serviceability limit states should normally be taken equal to 1,0.

(5)P …… This limiting value shall be agreed during the design of the supported structure

2.4.8 Serviceability limit states

(4) It may be verified that a sufficiently low fraction of the ground strength is mobilised to keep deformations within the required serviceability limits, provided this simplified approach is restricted to design situations where:

- a value of the deformation is not required to check the serviceability limit state;
- established comparable experience exists with similar ground, structures and application method.

2.4.9 Limiting values for movements of foundations

(1)P In foundation design, limiting values shall be established for the foundation movements.

NOTE Permitted foundation movements may be set by the National Annex.

(2)P Any differential movements of foundations leading to deformation in the supported structure shall be limited to ensure that they do not lead to a limit state in the supported structure.

NOTE In the absence of specified limiting values of structural deformations of the supported structure, the values of structural deformation and foundation movement given in Annex H may be used.

2.5 Design by prescriptive measures

(1) In design situations where calculation models are not available or not necessary, exceeding limit states may be avoided by the use of prescriptive measures. These involve conventional and generally conservative rules in the design, and attention to specification and control of materials, workmanship, protection and maintenance procedures.

NOTE Reference to such conventional and generally conservative rules may be given in the National annex.

(2) Design by prescriptive measures may be used where comparable experience, as defined in 1.5.2.2, makes design calculations unnecessary. It may also be used to ensure durability against frost action and chemical or biological attack, for which direct calculations are not generally appropriate.

2.5 Design by prescriptive measures
Example from DIN 1054:2005

Table A.1: Allowable bearing pressure σ_{allow} for strip foundations on non-cohesive soil based on sufficient bearing capacity (settlement ≤ 2.0 cm), subject to the conditions according to Table A.7

Smallest embedment depth of the foundation **m**	**Allowable bearing pressure σ_{allow}** **b or b' [kN/m²]**					
	0.50 m	1.00 m	1.50 m	2.00 m	2.50 m	3.00 m
0.50	200	300	400	500	500	500
1.00	270	370	470	570	570	570
1.50	340	440	540	640	640	640
2.00	400	500	600	700	700	700
For structures with embedment depths 0.30 m ≤ d ≤ 0.50 m and with foundation widths b or b' ≥ 0.30 m	150					

2.7 Observational method

(3)P During construction, the monitoring shall be carried out as planned.

(4)P The results of the monitoring shall be assessed at appropriate stages and the planned contingency actions shall be put into operation if the limits of behaviour are exceeded.

(5)P Monitoring equipment shall either be replaced or extended if it fails to supply reliable data of appropriate type or in sufficient quantity.

2.8 Geotechnical Design Report

(3) The Geotechnical Design Report should normally include the following items, with cross-reference to the Ground Investigation Report (see 3.4) and to other documents, which contain more detail:

- a description of the site and surroundings;
- a description of the ground conditions;
- a description of the proposed construction, including actions;
- design values of soil and rock properties, including justification, as appropriate;
- statements on the codes and standards applied;

2.8 Geotechnical Design Report

(3) The Geotechnical Design Report should normally include the following items, with crossreference to the Ground Investigation Report (see 3.4) and to other documents, which contain more detail (continued):

- statements on the suitability of the site with respect to the proposed construction and the level of acceptable risks;
- geotechnical design calculations and drawings;
- foundation design recommendations;
- a note of items to be checked during construction or requiring maintenance or monitoring.

2.8 Geotechnical Design Report

(4)P The Geotechnical Design Report shall include a plan of supervision and monitoring, as appropriate. Items, which require checking during construction or, which require maintenance after construction shall be clearly identified. When the required checks have been carried out during construction, they shall be recorded in an addendum to the Report.

2.8 Geotechnical Design Report

(5) In relation to supervision and monitoring the Geotechnical Design Report should state:

- the purpose of each set of observations or measurements;
- the parts of the structure, which are to be monitored and the locations at which observations are to be made;
- the frequency with which readings are to be taken;

(6) P An extract from the Geotechnical Design Report, containing the supervision, monitoring and maintenance requirements for the completed structure, shall be provided to the owner/client.