Workshop “Eurocodes: background and applications”
Brussels, 18-20 February 2008

General presentation of EUROCODE 7
‘Geotechnical design’

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1. Introduction

2. Contents of Eurocode 7 - Parts 1 & 2

3. Some aspects of Eurocode 7-1
   Characteristic values
   ULS Design Approaches
   SLS –Serviceability limit states
Basis of Structural design

Actions on structures

«Material » resistance

Geotechnical and seismic design

EN 1990

EN 1991

EN 1992
EN 1993
EN 1994

EN 1995
EN 1996
EN 1999

EN 1997
EN 1998
Eurocode 7 – Geotechnical design

**EN 1997-1 (2004)**: Part 1 - General rules

**EN 1997-2 (2007)**: Part 2 - Ground investigation and testing
2. Contents of Eurocode 7 – Parts 1 & 2
Contents of Part 1 (EN 1997-1)

Section 1 General

Section 2 Basis of geotechnical design

Section 3 Geotechnical data

Section 4 Supervision of construction, monitoring and maintenance

Section 5 Fill, dewatering, ground improvement and reinforcement
Contents of Part 1 (cntd)

Section 6  Spread foundations
Section 7  Pile foundations
Section 8  Anchorages
Section 9  Retaining structures
Section 10 Hydraulic failure
Section 11 Site stability
Section 12  Embankments
Informative annexes

Annexes D & E : Bearing capacity of foundations

\[ \frac{R}{A'} = c' \times N_c \times b_c \times s_c \times i_c + \]
\[ q' \times N_q \times b_q \times s_q \times i_q + \]
\[ 0.5 \times \gamma \times B' \times N_\gamma \times b_\gamma \times s_\gamma \times i_\gamma \]
\[ \frac{R}{A'} = \sigma_{v0} + k \times p_{le}^{*} \]

Annex C – Passive earth pressure

Annex F : Settlement of foundations

\[ s = \rho \times b \times f / E_m \]
Part 2 (EN 1997-2): Geotechnical design - Ground investigation and testing

Laboratory and field tests:

* essential requirements for the equipment and tests procedures

* essential requirements for the reporting and the presentation of results

* interpretation of test results and derived values

They are NOT test standards → see TC 341
Contents of Part 2 (EN 1997-2)

Section 1 General
Section 2 Planning and reporting of ground investigations
Section 3 Drilling, sampling and gw measurements
Section 4 Field tests in soils and rocks
Section 5 Laboratory tests on soils and rocks
Section 6 Ground investigation report

> Also a number of Informative annexes
3. Some aspects of Eurocode 7-1

Characteristic values and design values

ULS Design Approaches

SLS and deformations of structures
Geotechnical properties

Type of test
F= field L= laboratory

Correlations

Test results and derived values
EN 1997 -2
EN 1997 -1

Cautious selection

Geotechnical model and characteristic value of geotechnical properties

Application of partial factors

Design values of geotechnical properties

Information from other sources on the site, the soils and rocks and the project
Characteristic value of geotechnical parameters

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

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%.
Design values of geotechnical parameters

Design value of a parameter: \( X_d = \frac{X_k}{\gamma_M} \)

Design values of actions and resistances

fulfilling for STR/GEO ULS: \( E_d \leq R_d \)

\[ E_d = E \{\gamma_F F_k\} \quad \text{and} \quad R_d = R \{\frac{X_k}{\gamma_M}\} \]

(= “at the source”, MFA)

or \( E_d = \gamma_E E \{F_k\} \quad \text{and} \quad R_d = R \{\frac{X_k}{\gamma_R}\} \)

(RFA)
Ultimate limit states – Eurocode 7-1

- **EQU**: loss of equilibrium of the structure
- **STR**: internal failure or excessive deformation of the structure or structural elements
- **GEO**: failure or excessive deformation of the ground
- **UPL**: loss of equilibrium due to uplift by water pressure (buoyancy) or other vertical actions
- **HYD**: hydraulic heave, internal erosion and piping caused by hydraulic gradients
EN1990 - Ultimate limit states EQU and STR/GEO

$E_d < R_d$

J.A Calgaro
### Action ($\gamma_F$)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Set A1</th>
<th>Set A2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permanent</td>
<td>$\gamma_G$</td>
<td>1.35</td>
</tr>
<tr>
<td>Unfavourable</td>
<td>$\gamma_G$</td>
<td>1.00</td>
</tr>
<tr>
<td>Favourable</td>
<td>$\gamma_G$</td>
<td>1.00</td>
</tr>
<tr>
<td>Variable</td>
<td>$\gamma_Q$</td>
<td>1.50</td>
</tr>
<tr>
<td>Unfavourable</td>
<td>$\gamma_Q$</td>
<td>0.00</td>
</tr>
<tr>
<td>Favourable</td>
<td>$\gamma_Q$</td>
<td>0.00</td>
</tr>
</tbody>
</table>

### Soil parameter ($\gamma_M$)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Set M1</th>
<th>Set M2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angle of shearing resistance</td>
<td>$\gamma_{\varphi}'$</td>
<td>1.00</td>
</tr>
<tr>
<td>Effective cohesion</td>
<td>$\gamma_{c}'$</td>
<td>1.00</td>
</tr>
<tr>
<td>Undrained shear strength</td>
<td>$\gamma_{cu}$</td>
<td>1.00</td>
</tr>
<tr>
<td>Unconfined strength</td>
<td>$\gamma_{qu}$</td>
<td>1.00</td>
</tr>
<tr>
<td>Weight density</td>
<td>$\gamma_{\gamma}$</td>
<td>1.00</td>
</tr>
</tbody>
</table>

### Resistance ($\gamma_R$)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Set R1</th>
<th>Set R2</th>
<th>Set R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearing Portance</td>
<td>$\gamma_{Rv}$</td>
<td>1.00</td>
<td>1.40</td>
</tr>
<tr>
<td>Sliding</td>
<td>$\gamma_{Rh}$</td>
<td>1.00</td>
<td>1.10</td>
</tr>
</tbody>
</table>

$\gamma_R$ for Spread foundations.
STR/GEO : accidental situations

Actions : all values of $\gamma_F$ (and $\gamma_M$) = 1.0

Resistances : all values of $\gamma_R$ (and $\gamma_M$) depend on the particular accident

Seismic situations: see Eurocode 8-5
Ultimate limit states (UPL)

Examples of situations where uplift might be critical

\[ G_{\text{dst};d} + Q_{\text{dst};d} \leq G_{\text{stb};d} + R_d \]
Ultimate limit states (HYD)

Heave due to seepage of water

\[ u_{dst;d} \leq \sigma_{stb;d} \]
\[ \Delta u_{dst;d} \leq \sigma'_{stb;d} \]

Example of situation where heave or piping might be critical
Ultimate limit states of static equilibrium (EQU) :

\[ E_{d,\text{dst}} \leq E_{d,\text{stb}} \]

Ultimate limit states of resistance (STR/GEO) :

\[ E_d \leq R_d \]

Ultimate limit state of uplift (UPL) :

\[ G_{\text{dst};d} + Q_{\text{dst};d} \leq G_{\text{stb};d} + R_d \]

Ultimate limit state of hydraulic failure (HYD) :

\[ u_{\text{dst};d} \leq \sigma_{\text{stb};d} \quad \text{or} \quad S_{\text{dst};d} \leq G^*_{\text{stb};d} \]
EN1990 - Serviceability limit states SLS

Verifications:

\[ E_d \leq C_d \]

\( C_d = \text{limiting design value of the relevant serviceability criterion} \)

\( E_d = \text{design value of the effects of actions specified in the serviceability criterion, determined on the basis of the relevant combination} \)

All \( \gamma_F \text{ and } \gamma_M = 1.0 \)
Movements and deformations of structures

settlement $s$, differential settlement $\delta s$, rotation $\theta$ and angular strain $\alpha$

relative deflection $\Delta$ and deflection ratio $\Delta/L$

$\omega$ and relative rotation (angular distortion) $\beta$

(after Burland and Wroth, 1975)
Conclusions

Eurocode 7:

- a tool to help European geotechnical engineers speak the same language
- a necessary tool for the dialogue between geotechnical engineers and structural engineers

Eurocode 7 helps promoting research

- it stimulates questions on present geotechnical practice from ground investigation to design models
and to really conclude:

It should be considered that knowledge of the ground conditions depends on the extent and quality of the geotechnical investigations. Such knowledge and the control of workmanship are usually more significant to fulfilling the fundamental requirements than is precision in the calculation models and partial factors.
Thank you for your attention!