Update on Eurocode 7, its implementation and maintenance

Bernd Schuppener
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Implementation
• Legal framework for the implementation
• Review of the 1st Internat. Workshop 2006
• Questionnaires on the adoption of DA and Annexes

Maintenance
• General
• Corrigenda
• Limit state EQU
• Anchorages

Outlook
• Further harmonisation of Eurocodes
• Research for further harmonisation of EC 7
• User-friendliness of ECs
**Provisions for the implementation of Eurocodes in the European countries**

- The Eurocodes in the field of construction must be adopted and implemented by all EU member states.
- National standards are still permitted but national standards are not permitted to compete with European standards.
- Any national standard for which there is a corresponding European standard must therefore be withdrawn after a transitional period.
Future hierarchy of standards

Eurocode 1
Basis of design

Eurocode 2
Design of concrete structures

Eurocode 3
Design of steel structures

Eurocode 7
Geotechnical design

Eurocode 8

Eurocode 9

National Annex to EC 2

National Annex to EC 3

National Annex to EC 7-1

DIN 19702
Stability of solid structures in water engineering

DIN 19704
Hydraulic steel structures

DIN 1054:2007
Application rules to EC 7-1

DIN 4084
Calculation of slope failure

Code of practice
Stability of embankments on federal waterways

2nd International Workshop on Evaluation of Eurocode 7, Pavia, Italy, April 2010
International Workshop on the Evaluation of Eurocode 7

Trinity College, Dublin, 31 March and 1 April 2005
# Overview of the solutions to examples

<table>
<thead>
<tr>
<th>Example</th>
<th>Type</th>
<th>Parameter</th>
<th>Range of values</th>
<th>% range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Spread foundation</td>
<td>B</td>
<td>1.4 – 2.3 m</td>
<td>± 24 %</td>
</tr>
<tr>
<td>2</td>
<td>Spread foundation</td>
<td>B</td>
<td>3.5 – 9.9 m</td>
<td>± 48 %</td>
</tr>
<tr>
<td>3</td>
<td>Pile foundation</td>
<td>L</td>
<td>10.0 – 42.8 m</td>
<td>± 62 %</td>
</tr>
<tr>
<td>4</td>
<td>Pile foundation</td>
<td>N</td>
<td>9 or 10</td>
<td>± 5 %</td>
</tr>
<tr>
<td>5</td>
<td>Gravity ret. wall</td>
<td>D</td>
<td>3.1 – 6.0 m</td>
<td>± 32 %</td>
</tr>
<tr>
<td>6</td>
<td>Embedded ret. wall</td>
<td>D</td>
<td>3.8 – 6.9 m</td>
<td>± 29 %</td>
</tr>
<tr>
<td>7</td>
<td>Anchored ret wall</td>
<td>D</td>
<td>2.3 – 6.6 m</td>
<td>± 48 %</td>
</tr>
<tr>
<td>8</td>
<td>Uplift</td>
<td>T</td>
<td>0.41 – 1.11 m</td>
<td>± 46 %</td>
</tr>
<tr>
<td>9</td>
<td>Heave</td>
<td>H</td>
<td>4.7 – 8.1 m</td>
<td>± 27 %</td>
</tr>
<tr>
<td>10</td>
<td>Embankment</td>
<td>H</td>
<td>1.6 – 3.8 m</td>
<td>± 41 %</td>
</tr>
</tbody>
</table>

From Trevor Orr, 2005
Why such large ranges of values?

- Use of different Design Approaches
- Different interpretations of EC 7
- Use of different assumptions
- Use of different calculation models
- Bad examples – insufficient or unclear information
- Calculation errors
# Selection of Design Approach

<table>
<thead>
<tr>
<th>Design example</th>
<th>No/Incomplete answers</th>
<th>Design approach of EC 7-1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>all DAs</td>
<td>DA 1</td>
</tr>
<tr>
<td>Shallow foundation</td>
<td>N, CZ, M, S, LV, CY, IS, H, BG</td>
<td>IRL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piles</td>
<td>IRL</td>
<td>B, UK, P, LT, I, RO</td>
</tr>
<tr>
<td>Retaining structures</td>
<td>IRL</td>
<td>B, UK, P, LT, I, RO</td>
</tr>
<tr>
<td>Slopes</td>
<td>IRL</td>
<td>B, UK, P, LT, I, EST</td>
</tr>
</tbody>
</table>
| **Total:**       | **9**                 | **1**                     | **5 - 6**             | **2 - 14**             | **2 - 13**              | 2nd International Workshop on Evaluation of Eurocode 7, Pavia, Italy, April 2010
## Partial factors for slope stability

<table>
<thead>
<tr>
<th></th>
<th>DA 1</th>
<th>DA 2</th>
<th>DA 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial factors</td>
<td>Combination 1: $\gamma_G = 1.35$; $\gamma_{G,fav} = 1.0$; $\gamma_Q = 1.5$;</td>
<td>$\gamma_G = 1.35$; $\gamma_{G,fav} = 1.0$, $\gamma_Q = 1.5$; $\gamma_{R;e} = 1.10$; $\gamma_{\phi} = \gamma_c = 1.25$; $\gamma_{cu} = 1.40$; $\gamma_Q = 1.30$; $\gamma_{R;e} = 1.0$;</td>
<td>Recommended in EC 7-1</td>
</tr>
<tr>
<td>recommended in</td>
<td>Combination 2: $\gamma_{\phi} = \gamma_c = 1.25$; $\gamma_{cu} = 1.40$; $\gamma_G = 1.0$; $\gamma_Q = 1.30$; $\gamma_{R;e} = 1.0$;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EC 7-1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Application of the annexes of EC 7-1

(As at June -2007)

<table>
<thead>
<tr>
<th>Annex</th>
<th>Mandatory</th>
<th>Optional</th>
<th>Mandatory national standard</th>
<th>Future mandatory application?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annex C</strong>: earth pressures on vertical walls</td>
<td>SF, F, I, PL, SK,</td>
<td>SF, D, SK, PL</td>
<td>I: presumably not</td>
<td></td>
</tr>
<tr>
<td><strong>Annex D</strong>: bearing resistance calculation.</td>
<td>SF, F, I, PL, SK,</td>
<td>SF, D, SK, PL</td>
<td>I: presumably not</td>
<td></td>
</tr>
<tr>
<td><strong>Annex E</strong>: bearing resistance using pressuremeter</td>
<td>SF, F, I, PL, SK,</td>
<td>SF, SK,</td>
<td>D: not used in Germany I: presumably not</td>
<td></td>
</tr>
<tr>
<td><strong>Annex F</strong>: settlement evaluation</td>
<td>SF, F, I, PL, SK,</td>
<td>SF, D, SK, PL</td>
<td>I: presumably not, PL: must be changed</td>
<td></td>
</tr>
<tr>
<td><strong>Annex G</strong>: bearing resistance foundations on rock</td>
<td>SF, F, I, PL, SK,</td>
<td>SF, D, SK,</td>
<td>I: presumably not, PL: must be changed</td>
<td></td>
</tr>
<tr>
<td><strong>Annex H</strong>: Limiting values of foundation movement</td>
<td>F, I, PL, SK,</td>
<td>SF, SK, PL</td>
<td>D: not mandatory, I: presumably not</td>
<td></td>
</tr>
<tr>
<td><strong>Annex J</strong>: Checklists</td>
<td>SF, I, PL, SK,</td>
<td>SF</td>
<td>D: cannot be mandatory I: presumably not</td>
<td></td>
</tr>
</tbody>
</table>
Update on Eurocode 7 –
its implementation and maintenance

Maintenance
• General
• Corrigenda
• Limit state EQU
• Anchorages
Maintenance of Eurocodes

Maintenance is the technical and editorial improvement of Eurocodes which includes:

- essential technical amendments with regard to urgent matters of health,
- correcting errors and
- the resolution of questions of interpretation
- development of new items

resulting from feedback from use of Eurocodes.
Flowchart for the maintenance of Eurocodes

1. Technical comments
   - National Standard Body
     - Technical clarifications
     - Filtered comments

2. Maintenance Group of SC 7
   - Corrigenda
   - Clarifications
   - Amendments
     - Agreement of SC 7 on publication
     - Agreement of SC 7 on processing to vote

3. Acceptance of CEN/TC 250 on publication
Maintenance Group of SC 7


<table>
<thead>
<tr>
<th>Type of comments</th>
<th>EC 7-1</th>
<th>EC 7-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urgent technical or editorial corrections</td>
<td>≈ 50</td>
<td>≈ 40</td>
</tr>
<tr>
<td>Comments regarding editorial changes for the next version of the code</td>
<td>≈ 150</td>
<td>-</td>
</tr>
<tr>
<td>Comments needing further technical discussion</td>
<td>≈ 200</td>
<td>≈ 40</td>
</tr>
<tr>
<td>Total:</td>
<td>≈ 400</td>
<td>≈ 80</td>
</tr>
</tbody>
</table>

Publication of corrigendum of EC 7-1: February 2009
Publication of corrigendum of EC 7-2: March 2010
Definitions of ultimate limit state EQU

EN 1997-1 - Eurocode 7: Geotechnical Design:
“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”

EN 1990 - Eurocode: Basis of Design:
“Loss of static equilibrium of the structure or any part of it considered as a rigid body, where:
• minor variations in the value or the spatial distribution of actions from a single source are significant, and
• the strengths of construction materials or ground are generally not governing.”
Basic expression for the verification of ultimate limit state EQU

\[ E_{d,dst} \leq E_{d,stab} \]

- \( E_{d,dst} \): design value of effect of destabilising actions
- \( E_{d,stab} \): design value of effect of stabilising actions

\[ E\left\{ \gamma_{F,dst} F_{\text{rep,dst}} : X_k / \gamma_{M;a_{\text{nom}}} \right\} = E_{d,dst} \leq E_{d,stab} = E\left\{ \gamma_{F,stab} F_{\text{rep,stab}} : X_k / \gamma_{M;a_{\text{nom}}} \right\} \]

- \( F_{\text{rep,dst}} \): representative destabilising actions
- \( F_{\text{rep,stab}} \): representative stabilising actions
- \( \gamma_{F,dst} \): partial factors for destabilising actions
- \( \gamma_{F,stab} \): partial factors for stabilising actions
Partial factors for stabilising and destabilising actions for EQU limit states

<table>
<thead>
<tr>
<th>Actions</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>EN 1997-1 and EN 1990</td>
</tr>
<tr>
<td>Permanent, destabilising</td>
<td>$\gamma_{G,dst}$</td>
<td>1.10</td>
</tr>
<tr>
<td>Permanent, stabilising</td>
<td>$\gamma_{G,stab}$</td>
<td>0.90</td>
</tr>
<tr>
<td>Variable, destabilising</td>
<td>$\gamma_{Q,dst}$</td>
<td>1.50</td>
</tr>
<tr>
<td>Variable, stabilising</td>
<td>$\gamma_{Q,stab}$</td>
<td>0</td>
</tr>
</tbody>
</table>
Concepts for the interpretation and application of EQU limit state

Concept 1 proposes verifying EQU only in those cases where loss of static equilibrium is physically possible for the structure or part of it, considered as a rigid body and where no strength of the structure ground is involved. In situations where the strength of material or ground is significant in providing resistance Concept 1 proposes verifying STR/GEO only.

Concept 2 proposes verifying EQU in all cases; it is interpreted as a load case. Where minor strength of material or ground is involved, the combined EQU/STR/GEO verification is used.
Example: Balanced structure on piled foundation

<table>
<thead>
<tr>
<th>Partial factors</th>
<th>Concept 1</th>
<th>Concept 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>STR: applying SCP</td>
<td>STR: disregarding SCP</td>
</tr>
<tr>
<td>$\gamma_{G,\text{sup}}$</td>
<td>1.35</td>
<td>1.35</td>
</tr>
<tr>
<td>$\gamma_{G,\text{inf}}$</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>$\gamma_{G,\text{dst}}$</td>
<td>1.10</td>
<td>1.10</td>
</tr>
<tr>
<td>$\gamma_{G,\text{stb}}$</td>
<td>0.90</td>
<td>0.90</td>
</tr>
<tr>
<td>Design values $F_1$ and $F_2$</td>
<td>1.35 $W$</td>
<td>$W \cdot (1.175 \pm 0.35 \cdot a/b)$</td>
</tr>
<tr>
<td>Bending moment</td>
<td>0</td>
<td>$\pm 0.35 \cdot a \cdot W$</td>
</tr>
</tbody>
</table>

SCP: Single Source Principle
Example: beam structure – static equilibrium

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

**Concept 1**

Partial factors:
- EN 1990: Tab. A1.2(A), Note 1 and Tab. A1.2(B)
  - \( \gamma_{G,\text{dst}} = 1.10 \), \( \gamma_{G,\text{stb}} = 0.90 \), \( \gamma_{G,\text{sup}} = 1.35 \)

EQU-ULS:
- \( G_k \gamma_{G,\text{dst}} \leq G_k \gamma_{G,\text{stb}} + 2 A_k \)

Char. force \( A_k \):
- \( A_k \geq 0.11 G_k \)

Design force \( A_d \):
- \( A_d = A_k \gamma_{G,\text{sup}} = 0.148 G_k \)

**Concept 2**

Partial factors:
- EN1990: Table A1.2(a) Note 1
  - \( \gamma_{G,\text{stb}} = 1.10 \), \( \gamma_{G,\text{stb}} = 0.90 \)

EQU-ULS:
- \( G_k \gamma_{G,\text{sup}} \leq G_k \gamma_{G,\text{inf}} + 2 A_d \)

Char. force \( A_k \):
- not required

Design force \( A_d \):
- \( A_d = 0.10 G_k \)
Work on anchorages

Three standards dealing with anchorages:
• EN 1537:2001 Ground anchors (TC 288)
• EC 7-1: Section 8 Anchorages (SC 7)
• EN-ISO 22477-5: Testing of anchorages (WG 4, TC 341)

Decisions of TC 288, SC 7 and TC 341 on 13 July 2007:
• EN 1537 shall only deal with the execution of anchorages, so Annexes D (testing) and E (design) can be cancelled.
• All design issues shall be presented in EN 1997-1.
• All procedures for stress testing shall be covered in EN-ISO 22477-5.
• EN-ISO 22477-5 should cover the testing procedures of all member countries.
• All definitions and symbols shall be identical.
## Future contents of standards on anchorages

<table>
<thead>
<tr>
<th>EN-ISO: 22477-5 Testing of anchorages</th>
<th>EC7-1: Geotechnical design Part 1: General rules</th>
<th>EN 1537: Ground anchors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Common:</strong> terminology, definitions and symbols</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Scope&lt;br&gt;• Equipment&lt;br&gt;• Testing procedures&lt;br&gt;• Test report</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Section 8 “Anchorages”</strong>&lt;br&gt;• Design situations and actions&lt;br&gt;• Design and construction considerations&lt;br&gt;• ULS and SLS design&lt;br&gt;• All for special testing&lt;br&gt;• Number, method and type of test&lt;br&gt;• Requirements for proof loads, creep rates and group effects&lt;br&gt;• Determination of characteristic pull-out resistance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Scope&lt;br&gt;• Information for execution&lt;br&gt;• Geotechnical investigations&lt;br&gt;• Materials and products&lt;br&gt;• Design considerations(^1)&lt;br&gt;• Execution&lt;br&gt;• Supervision, monitoring and testing(^2)&lt;br&gt;• Records and design life condition monitoring&lt;br&gt;• Safety requirements</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Annexes (informative):</strong>&lt;br&gt;• Test methods including interpretation of test results</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Annex (informative):</strong>&lt;br&gt;• Recommended partial resistance and correlation factors for pre-stressed anchorages</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Annexes (informative):</strong>&lt;br&gt;• Testing of corrosion protection an acceptance criteria&lt;br&gt;• Examples of record sheets</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>National annexes:</strong>&lt;br&gt;• Selection of tests (number, type and method)&lt;br&gt;• Requirements for proof loads, creep rates and group effects&lt;br&gt;• Partial resistance and correlation factors</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) i.e. design input from execution<br>\(^2\) Other than stress testing, e.g. of bore holes and corrosion protection
Update on Eurocode 7 – its implementation and maintenance

Future tasks

- Further harmonisation of Eurocodes
- Research for further harmonisation of EC 7
- User-friendliness of ECs
Further harmonization of Eurocodes

"Member States should use the recommended values provided by the Eurocodes …. They should diverge from those recommended values only where geographical, geological or climatic conditions or specific levels of protection make that necessary."

"Member States should … compare the nationally determined parameters implemented by each Member State and assess their impact … . Member States should, at the request of the Commission, change their nationally determined parameters in order to reduce divergence from the recommended values provided by the Eurocodes."

Commission Recommendation, 11 December, 2003
"Member States should undertake research to facilitate the integration into the Eurocodes of the latest developments in scientific and technological knowledge. Member States should pool the national funding available for such research so that it can be used at Community level to contribute to the existing technical and scientific resources for research within the Commission, in cooperation with the Joint Research Centre, thus ensuring an ongoing increased level of protection of buildings and other civil works, specifically as regards the resistance of structures to earthquakes and fire."

Commission Recommendation, 11 December, 2003
The need for research for further harmonization of geotechnical design in Europe

by
Subcommittee 7 Geotechnical Design
of CEN/TC 250 Structural Eurocodes

Date: 29 June 2007
The need for research

Aims:

• Reduction of NDPs and their variety and a reduction of Design Approaches to come to a gradual alignment of safety levels across MS.
• Harmonization of the models used for the calculation of geotechnical actions and resistances,
• Harmonization of parameter evaluation from field and laboratory tests and
• Provisions for the application of numerical models (FEM) in Limit State Design.
Essential Requirements for Structures

- mechanical resistance and stability,
- safety in case of fire,
- safety in use,
- hygiene, health and the environment and protection against noise
- energy economy and heat retention and sustainable use of natural resources.
Essential Requirements for Structures

- mechanical resistance and stability,
- safety in case of fire,
- safety in use,
- hygiene, health and the environment and protection against noise
- energy economy and heat retention and sustainable use of natural resources.
Economic efficiency and Safety Level

Safety level vs. Cost effectiveness
Eurocode 7-1

2.4 Geotechnical design by calculation

2.4.1 General

(2) 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.
Essential components of geotechnical safety

• adequate knowledge of the structure and the mechanical characteristics of the ground,
• planning carried out by qualified staff,
• a realistic design model,
• adequate calculated safety of the design and
• adequate quality control on the construction site.
Geotechnical sustainability and safety

The safety level of geotechnical structures could be considerably increased if greater emphasis were placed

• on the extent and quality of soil investigations and
• on quality control during the construction of geotechnical engineering works.

It would then certainly be possible to discuss the reduction of the calculated safety and thus carry out construction work more economically and sustainably.