EUROCODE 7
& POLISH PRACTICE

Implementation of Eurocode 7 in Poland

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In Poland the designing with limit states and partial factors was introduced in 1974.

Foundations, retaining walls and similar structures were designed on the basis of a set of Polish Standards. The main of them include:

- PN-B 3020:1981 Shallow foundations. Geotechnical design
- PN-B 02482:1983 Bearing capacity of piles and pile foundations
- PN-B 03010:1983 Retaining structures. Geotechnical design

The standards generally use the concept of limit states and partial factors. However, in practice there are some exceptions for some problems (e.g. for slope stability), in which the use of global safety factor is more reasonable.
Polish versions of EC7


Supporting National Standards:
old standards: PN-81/B-03020, PN-83/B-03010, PN-83/B-02482 - all these standards need to be harmonised with Eurocode

Other supporting documents: Guide ... ITB (2011)
Design according to Eurocode 7
Guide

Building Research Institute
2011
There are also several standards which are harmonized with Eurocodes (particularly with the ENV ECs generation). They include:

PN-B-02481:1998 *Geotechnics. Basic terms and definitions*

PN-B-06050:1999 *Geotechnics. Earthworks*
As long as Minister’s decree (technical requirements for buildings) will not be changed in scope of reference of Polish Standards, Eurocodes as well as PN-B withdrawal, according to designer’s decision, may be the base of building design.
In Poland (according to relevant law) standards are in general not mandatory.

Polish Building Law and Ministries' regulations in many instances state that design shall be made according to standards (without precise indication - which standards?)
<table>
<thead>
<tr>
<th>Annex</th>
<th>Optional alternative</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annex C</strong>: Sample procedures to determine limit values of earth pressures on vertical walls</td>
<td>Standard PN-B-03010:1983. PN should be modified and harmonized with EC 7-1.</td>
</tr>
<tr>
<td><strong>Annex D</strong>: A sample analytical method for bearing resistance calculation</td>
<td>Standard PN-B-03020:1981. PN should be modified and harmonized with EC 7-1</td>
</tr>
<tr>
<td><strong>Annex E</strong>: A sample semi-empirical method for bearing resistance estimation</td>
<td>No similar Polish standard</td>
</tr>
<tr>
<td><strong>Annex F</strong>: Sample methods for settlement evaluation</td>
<td>Standard PN-B-03020:1981. PN should be modified and harmonized with EC 7-1</td>
</tr>
<tr>
<td><strong>Annex G</strong>: A sample method for deriving presumed bearing resistance for spread foundations on rock</td>
<td>No similar Polish standard</td>
</tr>
<tr>
<td><strong>Annex H</strong>: Limiting values of structural deformation and foundation movement</td>
<td>Requirements in Standard PN-B-03020:1981 are more detailed.</td>
</tr>
<tr>
<td><strong>Annex J</strong>: Checklist for construction supervision and performance monitoring</td>
<td>No similar Polish standard; Supervision and monitoring are dealt with in Polish building regulations.</td>
</tr>
</tbody>
</table>
National Annex

- The scope of Ground Investigation for Geotechnical Categories
- National choice of Design Approach for slopes - DA3
- Other than slopes - DA2* (GEO - Design bearing resistance eq. 2.7b, characteristic values and $\gamma_F = 1.0$)
- HYD - Hydraulic failure by heave - eq. 2.9b
Reasons for DA2* selection:
• is the most similar to our current practice
• was chosen by many countries, including Germany, whose practice is most similar to ours
• simplify calculation due to less of loading combinations (checks with $\gamma_G <1$ and $>1$ are not needed)
• allows in many cases for simple evaluation of reliability ratio of the structure, required in EC7

Reasons for selection of DA3 for slopes:
• it is more rational then DA2 for slopes
• is similar to current rules of stability verification
NA: The scope and methods of the subsoil investigations as well as geotechnical parameters for the structural design are determined by the author of geotechnical design report (geotechnical conditions of foundation) with co-operation with the structural designer.

There is general practice that geotechnical investigation report contains table with geotechnical parameters values for each layer.
Beata Gajewska – Road and Bridge Research Institute

**Minimum requirements for the scope of the ground investigation (Table NA.1)**

<table>
<thead>
<tr>
<th>Geotechnical category</th>
<th>Scope of the subsoil investigation</th>
</tr>
</thead>
</table>
| **Structures classified to the 1\textsuperscript{st} geotechnical category in simple ground conditions** | - qualitative determination of the ground properties on the basis of:  
  • archival data analysis  
  • comparable experience considered  
  • field investigation                                                                                                                                                                      |
| **Structures classified to the 2\textsuperscript{nd} geotechnical category in simple and complex ground conditions** | - quantitative determination of numerical values of geotechnical parameters on the basis of:  
  • archival data analysis and comparable experience considered  
  • field investigation results  
  • laboratory investigation results                                                                                                                                 |
The Annex H was supplemented by the following recommendations:

It is recommended to verify the limit states for construction settlements on the basis of displacement and deformation values: \( s_{\text{max}}, \theta_{\text{max}}, \Delta_{\text{max}}, \omega \).

Limit values of displacement and deformation values for buildings:
- for commonly used structures
- with no special requirements referring to the settlements (limit values according to Table NA.3)

<table>
<thead>
<tr>
<th>( s_{\text{max}} ) [mm]</th>
<th>( \theta_{\text{max}} ) [rad]</th>
<th>( \Delta_{\text{max}} ) [mm]</th>
<th>( \omega ) [rad]</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>0.002</td>
<td>10</td>
<td>0.003</td>
</tr>
</tbody>
</table>
Polish NA accepts in general the partial factor values recommended in EC 7-1 Annex A.

There are two exceptions:

• in case of specific risk, complicated soil conditions or/and unusual loads (structures classified to the 3rd geotechnical category) - more unfavourable values of partial factors than those given in the Annex A may be justified.

• for temporary structures or transient design situations - less severe values of partial factors may be justified

The use of more unfavourable or less severe values of partial factors should be justified in the design.
### Spread foundations
**(inclined eccentric loading)**

ULS design of spread foundation for a tower on cohesive soil:

- $\gamma_k' = 25 \, \text{kN/m}^3$
- $\phi_k' = 26^\circ$
- $c_k' = 10 \, \text{kPa}$

**Ground surface**

- Horizontal action $H_{Q,k} = 200 \, \text{kN}$
- Vertical action $V_{G,k} = 1500 \, \text{kN}$

**Drained conditions**

<table>
<thead>
<tr>
<th></th>
<th>DA1(1)</th>
<th>DA1(2)</th>
<th>DA2</th>
<th>DA2*</th>
<th>DA3</th>
<th>PN</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bearing capacity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Lambda_{GEO}$ %</td>
<td>88,5</td>
<td>181,7</td>
<td>123,9</td>
<td>98,6</td>
<td>156,5</td>
<td>102,8</td>
</tr>
<tr>
<td><strong>Utilization factor for bearing capacity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sliding resistance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Lambda_{GEO}$ %</td>
<td>33,0</td>
<td>35,7</td>
<td>36,3</td>
<td>36,3</td>
<td>41,2</td>
<td>30,6</td>
</tr>
</tbody>
</table>

Lechowicz et al.
Spread foundations
(Inclined eccentric loading)

ULS design of spread foundation for a tower on non-cohesive soil

\[ \gamma_k' = 20 \text{ kN/m}^3 \]
\[ \phi_k' = 32^\circ \]
\[ c_k' = 0 \text{ kPa} \]

Lechowicz et al.

<table>
<thead>
<tr>
<th>Drained conditions</th>
<th>DA1(1)</th>
<th>DA1(2)</th>
<th>DA2</th>
<th>DA2*</th>
<th>DA3</th>
<th>PN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearing capacity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utilization factor for bearing capacity</td>
<td>( \Lambda_{GEO} ) %</td>
<td>39,8</td>
<td>83,9</td>
<td>55,7</td>
<td>47,7</td>
<td>80,6</td>
</tr>
<tr>
<td>Sliding resistance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utilization factor for sliding resistance</td>
<td>( \Lambda_{GEO} ) %</td>
<td>20,0</td>
<td>21,7</td>
<td>22,0</td>
<td>22,0</td>
<td>25,0</td>
</tr>
</tbody>
</table>
EC7-1 and PN-B-03020 - difference in characteristic values:

EC7-1 - with a confidence level of 95% or directly determined - expert’s values

PN - mean values or taken from table in the Standard, exceptionally expert’s values
Spread foundations

**ULTIMATE LIMITE STATE ULS (2.4.7.)**

<table>
<thead>
<tr>
<th>PN-81/B-03020</th>
<th>EUROCODE 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Bearing resistance failure</td>
<td>1. EQU EQUilibrium</td>
</tr>
<tr>
<td>2. General stability/Circular slip</td>
<td>2. STR STRuctural</td>
</tr>
<tr>
<td>3. Sliding resistance</td>
<td>3. GEO GEOtechnical</td>
</tr>
<tr>
<td></td>
<td>4. UPL UPLift</td>
</tr>
<tr>
<td></td>
<td>5. HYD HYDraulic heave</td>
</tr>
</tbody>
</table>

and structural design
Structure reliability approach

Limit states methods in previous Polish Standards are methods, in which appropriate level of reliability of a structure was achieved by using a set of partial factors modifying representative values of variables deciding upon condition of a structure.

Calibration of reliability measures - i.e. calibration of partial factor values recommended in Polish NA is needed, especially in the case of some types of foundations, e.g. piles.

Simplified probabilistic methods with the use of reliability ratio β and probabilistic methods in geotechnical design are rather not used.
Structure reliability approach

After 30 years from introduction of Standards based on semi probabilistic method of limit states there exists a general view, that acceptance of slight risk of failure of every structure is unavoidable, and fundamental variables taken into account in the design process are usually unreliable.

The Polish TC 254 Geotechnics initiated action aiming at common approach to the reliability of the structure from the loadings point of view (EC0 and EC1) and geotechnical resistances (EC7), and, consequently, a common calibration of reliability measures.
Piles according to Eurocode and PN-B-02482
resistance from ground test results

For a building assumed 70% of loadings is dead weight, 30% - live loads
Piles - partial factors for:

<table>
<thead>
<tr>
<th>loads:</th>
<th>PN-B-02482</th>
<th>Eurocode7-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0.7x1,1 + 0.3x1,2) = 1.13</td>
<td>(0.7x1,35 + 0.3x1,5) = 1.395</td>
<td></td>
</tr>
<tr>
<td>parameters:</td>
<td>1/0.9 = 1.11</td>
<td>1.4 - 1.25</td>
</tr>
<tr>
<td>resistance:</td>
<td>1/0.9* (0.8; 0.7) = 1.11</td>
<td>1.1</td>
</tr>
<tr>
<td>total factor:</td>
<td>1.13:0.9:0.9 = 1.4</td>
<td>1.395x(1.25-1.4)x1.1 = 1.92-2.15</td>
</tr>
</tbody>
</table>

m = 0.9 for 3 and more piles, 0.8 for 2 piles, 0.7 for 1 pile

Ratio (1.92 - 2.15) : 1.4 = 1.37 - 1.54 !

Comment: The shaft and base resistances given in PN-B-02482 are "design limit value", i.e. reduced - equivalent settlement of about 5% of diameter. EC7 limit resistance corresponds to the settlement equal to 10% of diameter.

Significant impact on the result has the number of tests or profiles

Factor F according to EC7 is even greater because of the way of determining the characteristic resistances
Evolution groups

and what else ...

Should be added or expanded in EC7

• structures design involving various ground improvement techniques

• The use of Observational Method
Implementation of EC 7 in Poland

• Conferences, seminars and workshops
  - XV NCSMGE, Bydgoszcz 2009
  - XI Baltic Sea Geotechnical Conference, Gdańsk 2008
  - 57 Conference of Civil Engineering Committee, Krynica 2011
  - Seminars: „Implementation of EC7”, Pułtusk 1999; Building Research Institute, Warsaw 2010
  - Workshop for Civil Engineering Designers, Wisła 2010

• Postgraduate study „Geotechnical design”
  - WULS - SGGW in Warsaw
  - Cracow University of Technology
  - and others
Implementation of EC 7 in Poland

- **WWW**
  - http://pkg-bialystok.pb.edu.pl/eurokod
  - e-learning

- **PKG (Polish Geotechnical Committee)** - Commission for Implementation of EC7

- **PKN (Polish Committee for Standardization)**
  KT 254 Geotechnics

- **Courses** - PIIB Polish Chamber of Civil Engineers, others
Conclusion

Eurocode 7 is not easy to use, despite similarity to previous Polish Standards

The statements in EC7 are often more general, than a designer (used to more detailed standards) would expect

More details on determination of characteristic values of geotechnical parameters are needed - parameters' values should be adjusted to the kind and features of a specific structure

Common approach to the reliability of a structure from the loadings point of view (EC0 and EC1) and geotechnical resistances (EC7), contribute to improving the design’s economy, while provide safety of a structure
Thank You!