EUROCODE 7
Water pressures - safety approach
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April 6th, 2010
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Example 1 - EQU

For EQU – overturning moment at point A

Waterpressures $u_1$ and $u_2$ are destabilising
Weight $W$ is stabilising

$M_{dst} \times \gamma_{dst} \leq M_{st} \times \gamma_{st}$

In NL $\gamma_{dst} = 1.1$ $\gamma_{st} = 0.9$ (NA - Table A.1)
**Example 1 - STR/GEO → DA3 (NL)**

**Sliding** (eq. 6.2) + (eq. 6.3a)

- Action $H = 0.5 \times u_1 \times h$
- Uplift $Upl = b \times 0.5 \times (u_2 + u_3)$
- Resistance $R = (W - Upl) \times \tan \delta$

Design load $H_d = \gamma_{G;dst} \times 0.5 \times u_1 \times h$ ($\gamma_{G;dst} = 1.2$ water)

**Bearing capacity** (eq. 6.1)

- Action $V = W - Upl$
- Horizontal $H = 0.5 \times u_1 \times h$

Design load

- Maximum load $V_d = (1.35 \times W - 0.9 \times Upl)$
- Minimum load $V_d = (0.9 \times W - 1.2 \times Upl)$

Resistance bearing capacity $R_d$ based on $c_d', \varphi_d', c_{udr}, \gamma_d' = (\gamma_{sat;d} - 10)$ load inclination factor $i$ based on $H_d$ and $V_d$

$V_d \leq R_d$ to be checked both for maximum and minimum load
Example 2 - UPL

In case of one and the same water regime (see Vogt)

\[(W - \gamma_w H B) \times \gamma_{G;stb} \geq F \times \gamma_{Q;dstb}\]

In the exceptional case of a different regime between water and groundwater compute the uplift as a destabilising force and the downward pressure as a stabilising force:

\[W \times \gamma_{G;stb} + U_{stb} \times \gamma_{G;stb} \geq U_{dst} \times \gamma_{G;dstb} + F \times \gamma_{Q;dstb}\]
Example 3 - UPL + STR/GEO

This case is interesting because of the computation of the tensile load $F_t$ on the anchors/anchor piles.

Two Ultimate Limit States to be considered: UPL and STR/GEO.

**UPL considers the total uplift**

\[
\gamma_{G;stb} \cdot W + R_d \geq \gamma_{G;dstb} \cdot V_{dst}
\]
\[
0,9 \cdot W + R_d \geq 1,0 \cdot V_{dst}
\]

ignoring wall friction → load on piles $R_d = \Sigma F_{td} = 1,0\cdot V_{dst} - 0,9\cdot W$

**STR/GEO considers the load on one pile** (eq. 2.5) $E_d \leq R_d$

\[
E_d = 1,2\cdot V_{dst} - 0,9\cdot W
\]

($V_{dst} = UPL$, water pressure $\gamma_{G;dst} = 1,2$)

\[
R_d = F_{t;d}
\]

→ load on pile $F_{t;d} = 1,2\cdot V_{dst} - 0,9\cdot W$ (governing)
Groundwater pressure derivation

EC 7-2 Annex C statistical method to predict groundwater pressure
Groundwater pressure derivation

EC 7-1
2.4.6.1(1)P design value of an action shall either be assessed directly or shall be derived from representative values by applying partial factors

- assessed directly see (6)P
- applying partial factors \( F_d = \gamma_F \cdot F_{\text{rep}} \) \( \gamma_F = 1,2 \)

2.4.6.1(6)P design values of groundwater pressures ULS shall represent the most unfavourable values that could occur during the design lifetime

- as a consequence \( \gamma_F = 1,0 \)

2.4.6.1(8) design values of groundwater pressures may be derived by applying partial factors or by applying a safety margin to the characteristic level

- applying partial factors \( F_d = \gamma_F \cdot F_{\text{rep}} \)
- applying safety margin \( F_d = F_{\text{rep}} + \Delta a \cdot \gamma_w \cdot \text{Area} \)
Groundwater pressure: example

Watertable Level +3 m +/- 1 m

Waterpressure A
\[ V_d = 21.6 \text{ kPa} \]

In NL: loadfactor on waterpressure is 1.2!

Waterpressure B
\[ V_d = 86.4 \text{ kPa} \]
Groundwater pressure: example

Watertable: most unfavourable value in lifetime (extrapolated from some statistical analysis of standpipe records): Level + 4 m.

- **Case A**  
  - most unfavourable value → uplift pressure 18 kPa → $\gamma F = 1,0$
  - loadfactor → uplift pressure = 21.6 kPa → $\gamma F = 1,2$
  - margin $a = 0.5$ m → waterlevel + 4.5 m, $w = 23$ kPa → $\gamma F = 1,28$

- **Case B**  
  - most unfavourable value → uplift pressure 72 kPa → $\gamma F = 1,0$
  - loadfactor → uplift pressure = 86.4 kPa (impossible) → $\gamma F = 1,2$
  - margin $a = 0.5$ m → waterlevel + 4.5 m, $w = 77$ kPa → $\gamma F = 1,07$

Question: what design waterpressure do we take?