EUROCODE 7
Water pressures - safety approach

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April 6th, 2010

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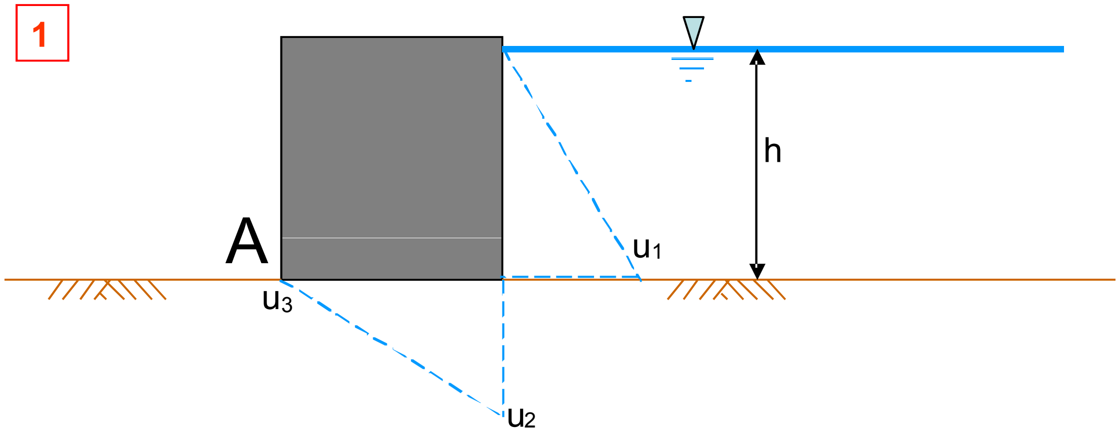
Example 1 - EQU



For EQU – overturning moment at point A

Waterpressures u_1 and u_2 are destabilising

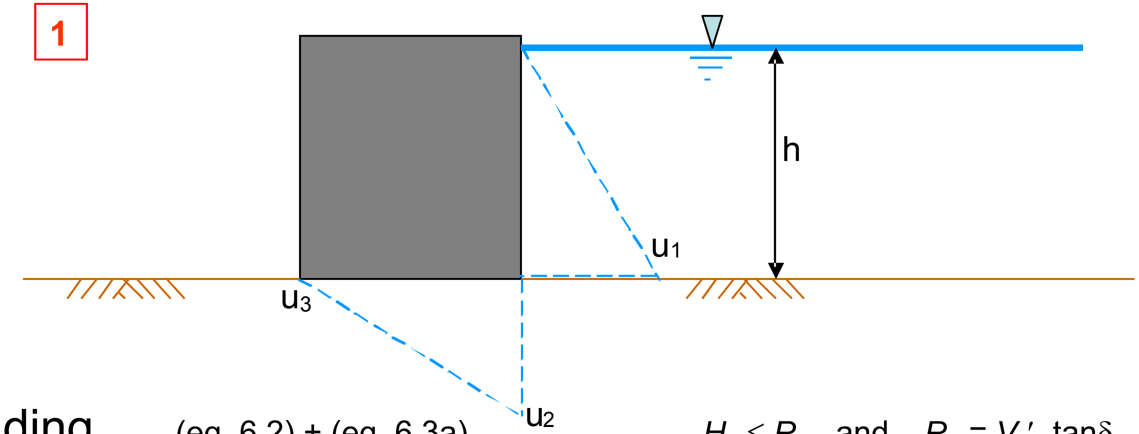
Weight W is stabilising

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

In NL $\gamma_{dst} = 1,1$ $\gamma_{st} = 0,9$ (NA - Table A.1)

Example 1 - STR/GEO → DA3 (NL)

1



Sliding

(eq. 6.2) + (eq. 6.3a) — $H_d \leq R_d$ and $R_d = V'_d \tan\delta_d$

Action $H = 0,5 * u_1 * h$ — Design load $H_d = \gamma_{G;dst} * 0,5 * u_1 * h$ ($\gamma_{G;dst}$ = 1,2 water)

Uplift Upl = b * 0,5 ($u_2 + u_3$)

Resistance $R = (W - U_{pl}) * \tan\delta$ — Design resistance $R_d = (0,9*W - 1,2*Upl) * (\tan\delta) / \gamma_{\varphi'}$

Bearing capacity (eq. 6.1)

$V_d \leq R_d$

Action V = W-Upl — Design load V_d = (1,35*W – 0,9*Upl) maximum load

V_d = (0,9*W – 1,2*Upl) minimum load

Horizontal $H = 0,5 * u_1 * h$ — Design load $H_d = 0.9 * 0,5 * u_1 * h$ with maximum load

H_d = 1.2 * 0,5 * u1 * h with miniimum load

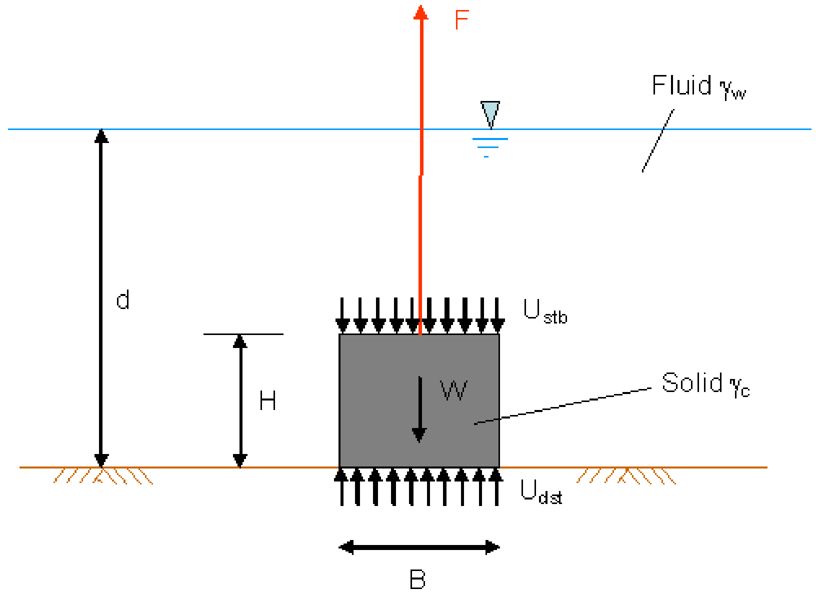
Resistance — bearing capacity R_d based on c_d', φ_d', $c_{u;d}$, $\gamma'_d = (\gamma_{sat;d} - 10)$

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

2



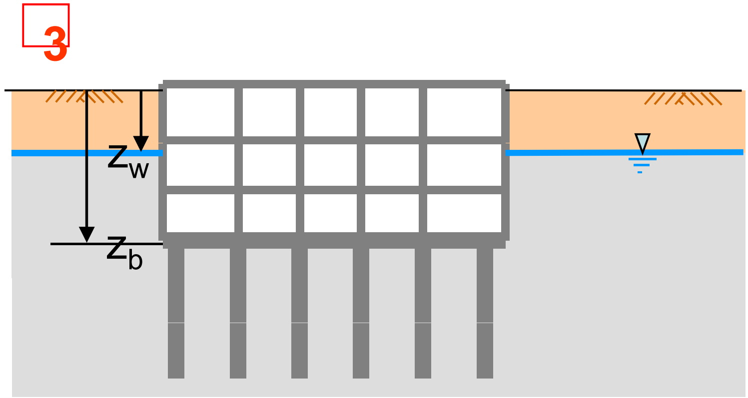
In case of one and the same water regime (see Vogt)

$(W - \gamma_w * H * B) * \gamma_{G;stb} \geq F * \gamma_{Q;dstb}$

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:

$W * \gamma_{G;stb} + U_{stb} * \gamma_{G;stb} \geq U_{dst} * \gamma_{G;dstb} + F * \gamma_{Q;dstb}$

Example 3 - UPL + STR/GEO



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

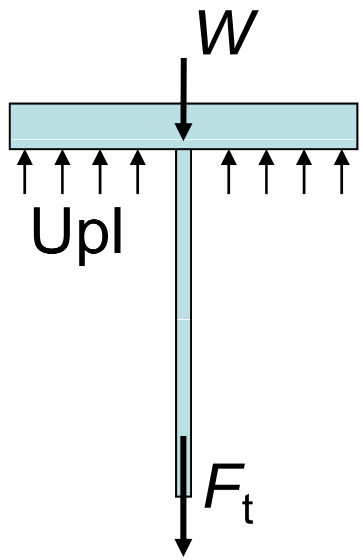
Two Ultimate Limit States to be considered: UPL and STR/GEO

UPL considers the total uplift

$\gamma_{G;stb} * W + R_d \geq \gamma_{G;dstb} * V_{dst}$ $\quad V_{dst} = \gamma_w (z_w - z_b) * \text{Area}$

$0{,}9 * W + R_d \geq 1{,}0 * V_{dst}$

ignoring wall friction $\rightarrow$ load on piles $R_d = \Sigma F_{t;d} = 1{,}0 * V_{dst} - 0{,}9 * W$



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

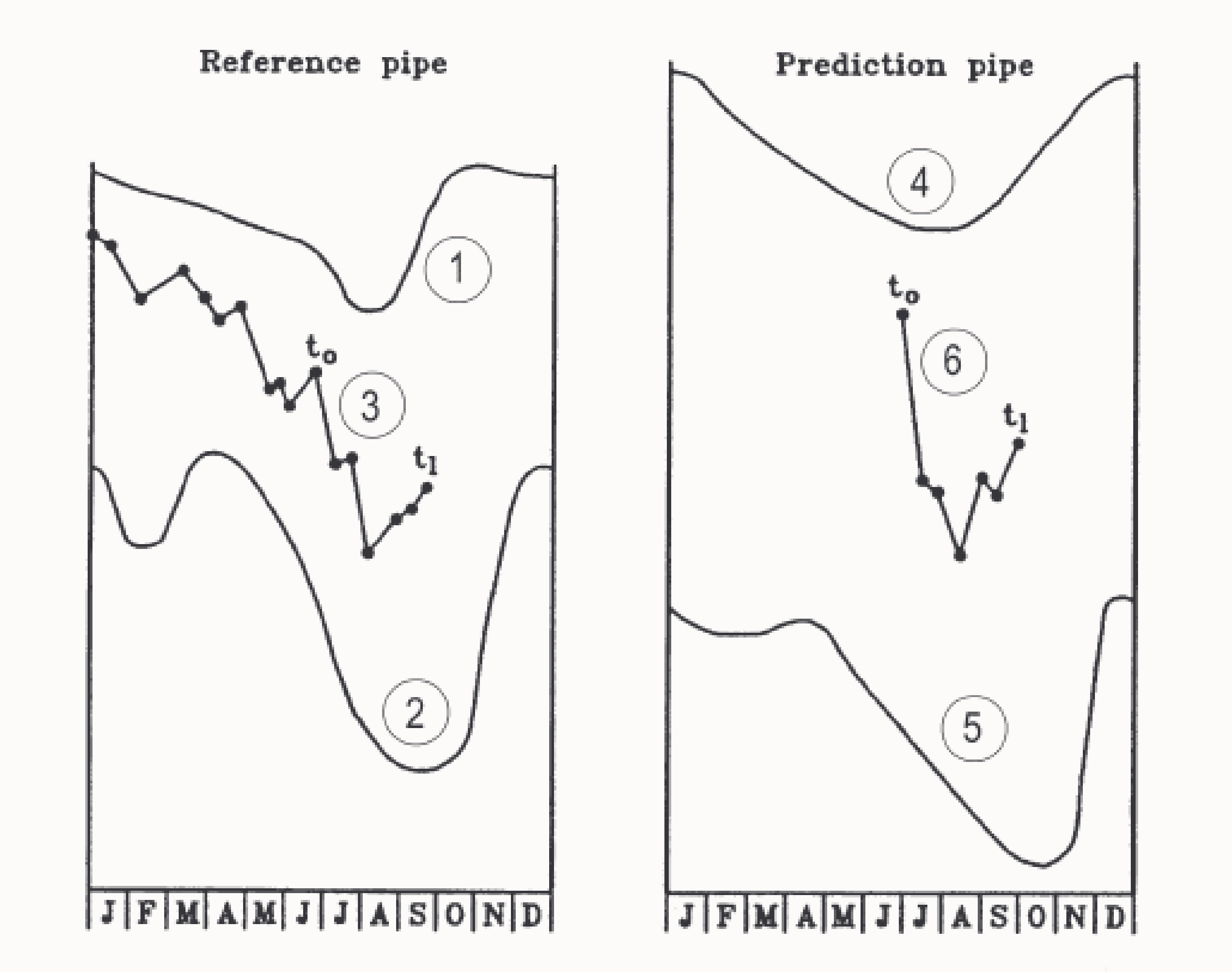
$E_d = 1{,}2 * V_{dst} - 0{,}9 * W$ $\quad$ (V_{dst} = UPL, waterpressure $\gamma_{G;dst} = 1{,}2$)

$R_d = F_{t;d}$

$\rightarrow$ load on pile $F_{t;d} = 1{,}2 * V_{dst} - 0{,}9 * W$ (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 $F_d = \gamma_F \cdot F_{rep}$ $\gamma_F = 1{,}2$

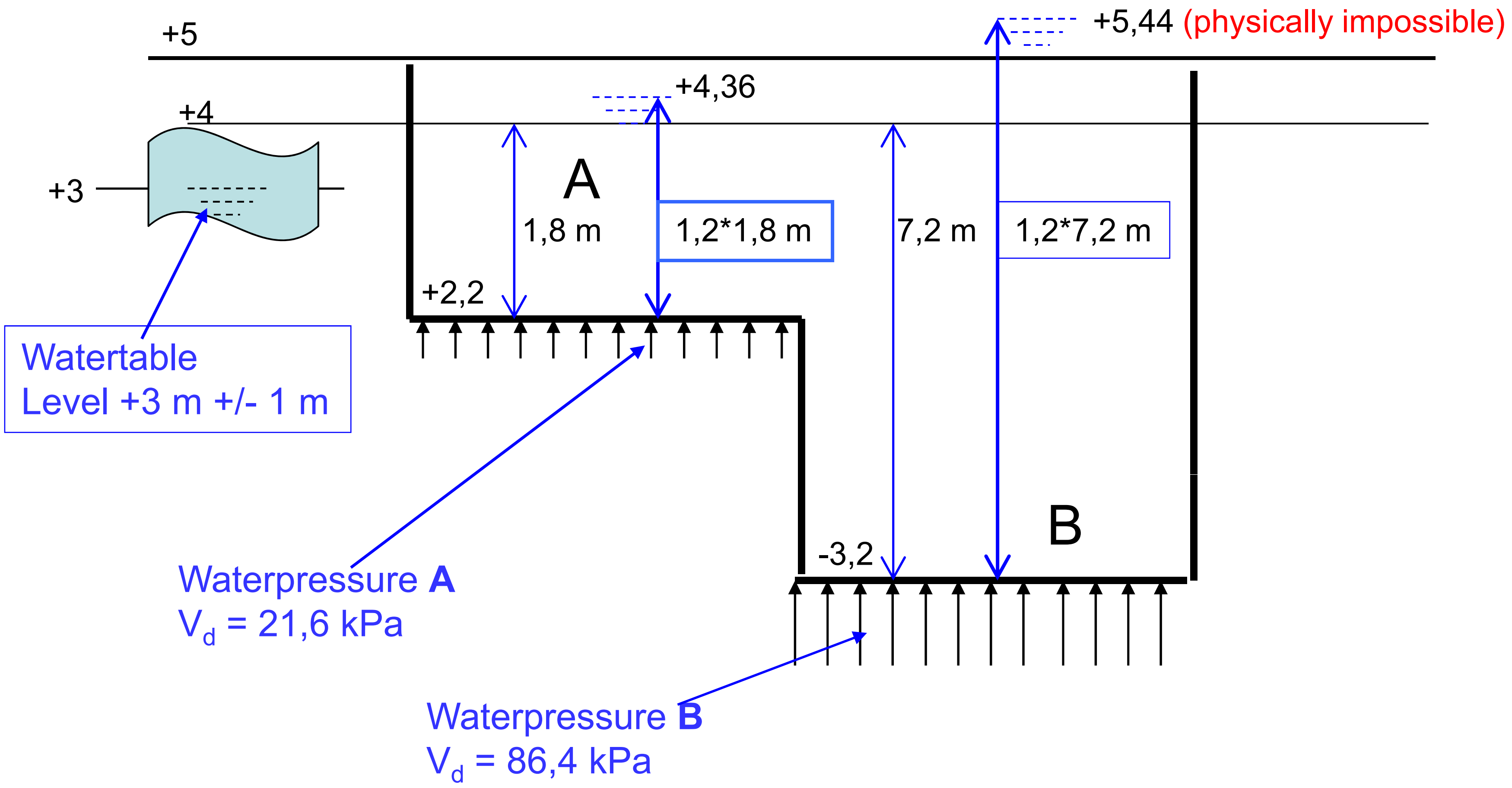
2.4.6.1(6)P design values of groundwater pressures ULS shall represent the most unfavourable values that could occur during the design lifetime

- 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 $F_d = \gamma_F \cdot F_{rep}$
- applying safety margin $F_d = F_{rep} + \Delta a.\gamma_w.\text{Area}$

Groundwater pressure: example



In NL: loadfactor on waterpressure is 1.2!

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?