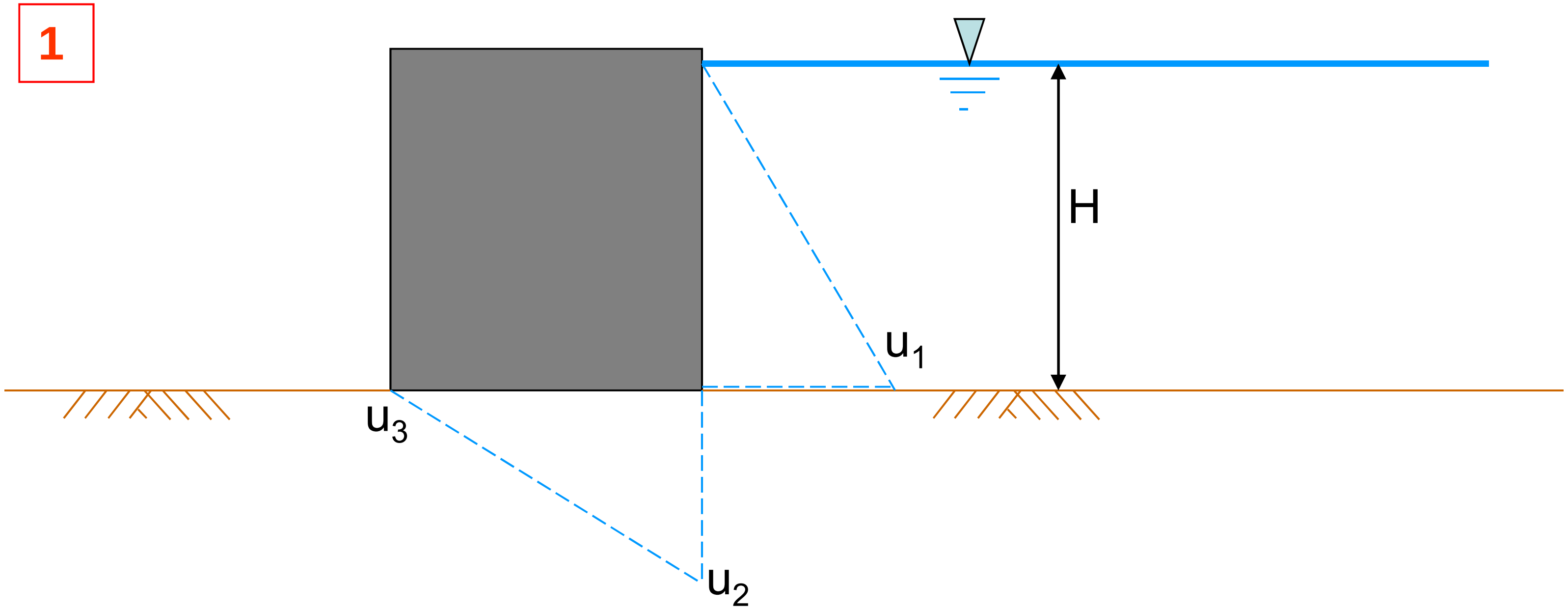
1




Sliding check: Horizontal characteristic action is $u_1 \cdot H^2/2$

vertical characteristic action is the weight W of the caisson

reduced by uplift $Upl = B \cdot (u_3 + u_2)/2$

Resistance against sliding $(W - Upl) \cdot \tan\varphi$

Verification: $\gamma_G \cdot u_1 \cdot H^2/2 \leq (W - Upl) \cdot \tan\varphi / \gamma_{R,h}$

bearing capacity check: DA 2*

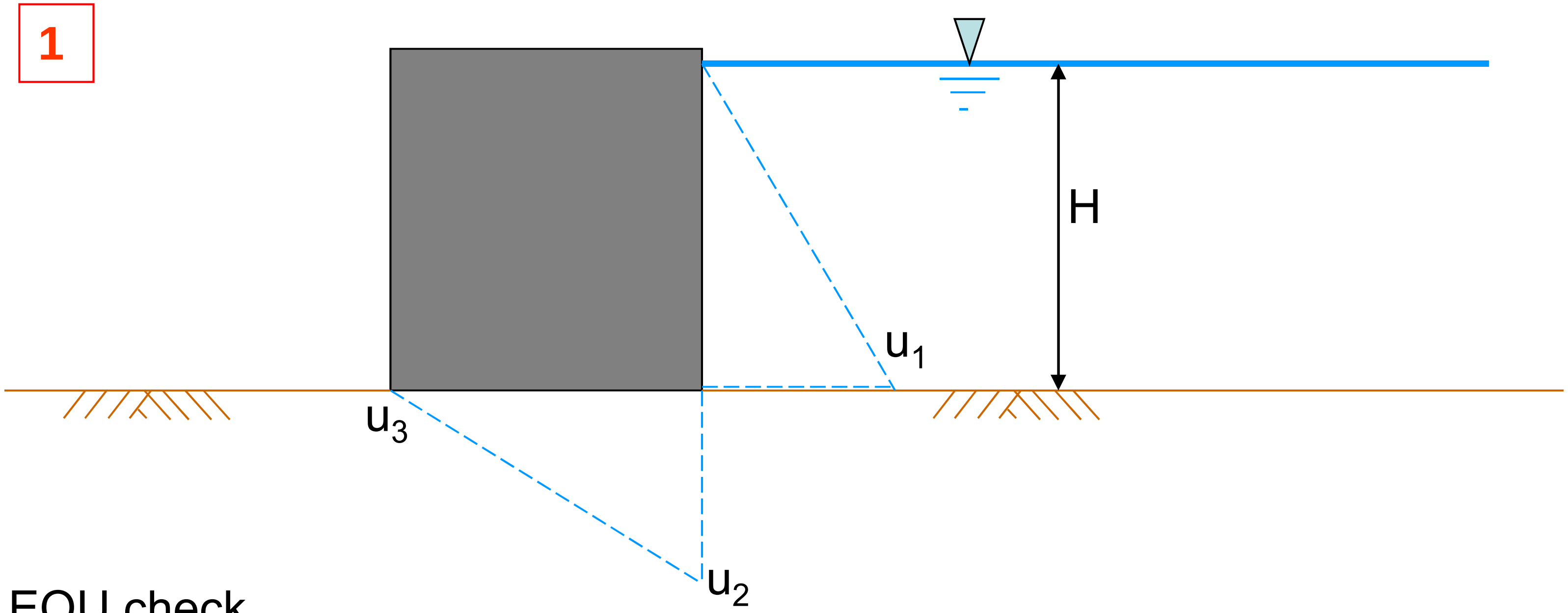
find characteristic vertical load (Weight – Uplift) (characteristic values)

find characteristic load inclination and characteristic load excentricity

to evaluate the characteristic bearing capacity

Compare characteristic (weight – uplift)$\cdot\gamma_G \leq$ characteristic bearing capacity / $\gamma_{Gr}$

1




EQU check

calculate characteristic moments due to horizontal water pressure (destabilising), vertical water pressure (destabilising) and selfweight (stabilising) referred to the centre of the footing

$$\sum M_{dst} \cdot \gamma_{dst} \leq \sum M_{stb} \cdot \gamma_{stb}$$

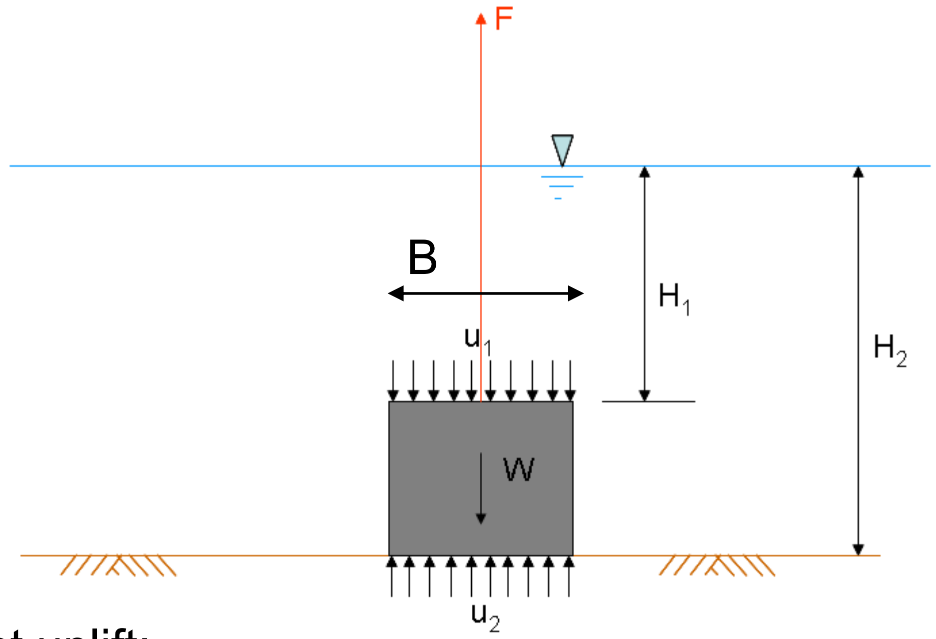
internal structural check

calculate characteristic effects of action and then take following verification

$$E_d = \gamma_{G,sup} \cdot \sum_{j(sup)} E_{Gk,j} + \gamma_{G,inf} \cdot \sum_{j(inf)} E_{Gk,j} + \gamma_P \cdot E_{Pk} + \gamma_Q \cdot \left( E_{Qk,1} + \sum_{i>1} \psi_{0,i} \cdot E_{Qk,i} \right)$$

$$\leq R\left( \alpha \cdot \frac{f_{ck}}{\gamma_c}; \frac{f_{yk}}{\gamma_s}; \frac{f_{tk,cal}}{\gamma_s}; \frac{f_{p0,1k}}{\gamma_s}; \frac{f_{pk}}{\gamma_s} \right) = R_d$$

2




<u>Verification against uplift</u>:

$$W \cdot \gamma_{G,stb} + B \cdot \gamma_W \cdot H_1 \cdot \gamma_{G,stb} \geq B \cdot \gamma_W \cdot H_2 \cdot \gamma_{G,dst} + F \cdot \gamma_{Q,dst}$$

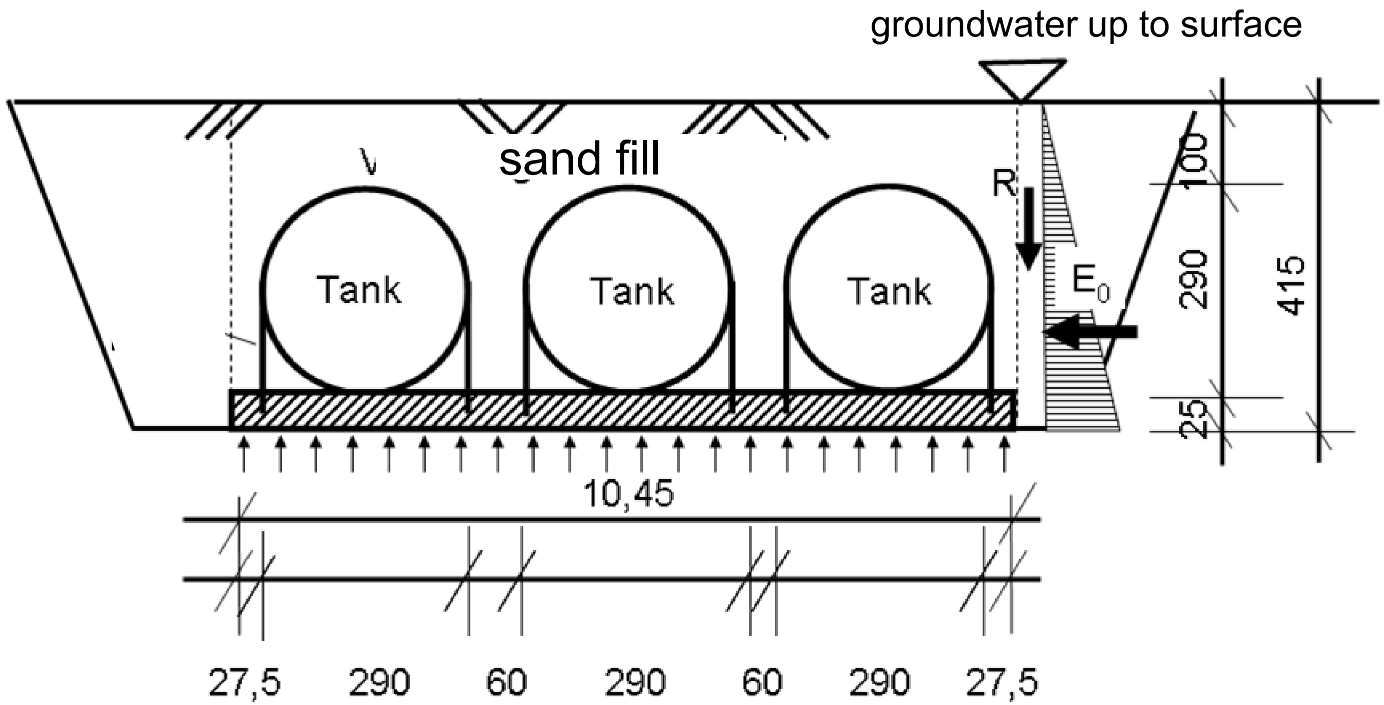
This is an easy format using simple forces and it is easy to include overlaying soil using it‘s effective unit weight $\gamma$‘ . But it violates the single source principle and leads to different „safe“ forces F for different depths of the „lake“

Alternatively we could define the buoyancy Upl = $B \cdot \gamma_W \cdot (H_2 - H_2)$ as a resultant destabilizing force leading to

$$W \cdot \gamma_{G,stb} \geq B \cdot \gamma_W \cdot (H_2 - H_1) \cdot \gamma_{G,dst} + F \cdot \gamma_{Q,dst}$$

Both solutions are correct. In reality there is no increasing factor to the water weight. Nor at the upper side, nor at the bottom side, nor according to buoyancy!
It is up to us to give a rule to european engineers

# Uplift-verification for tanks

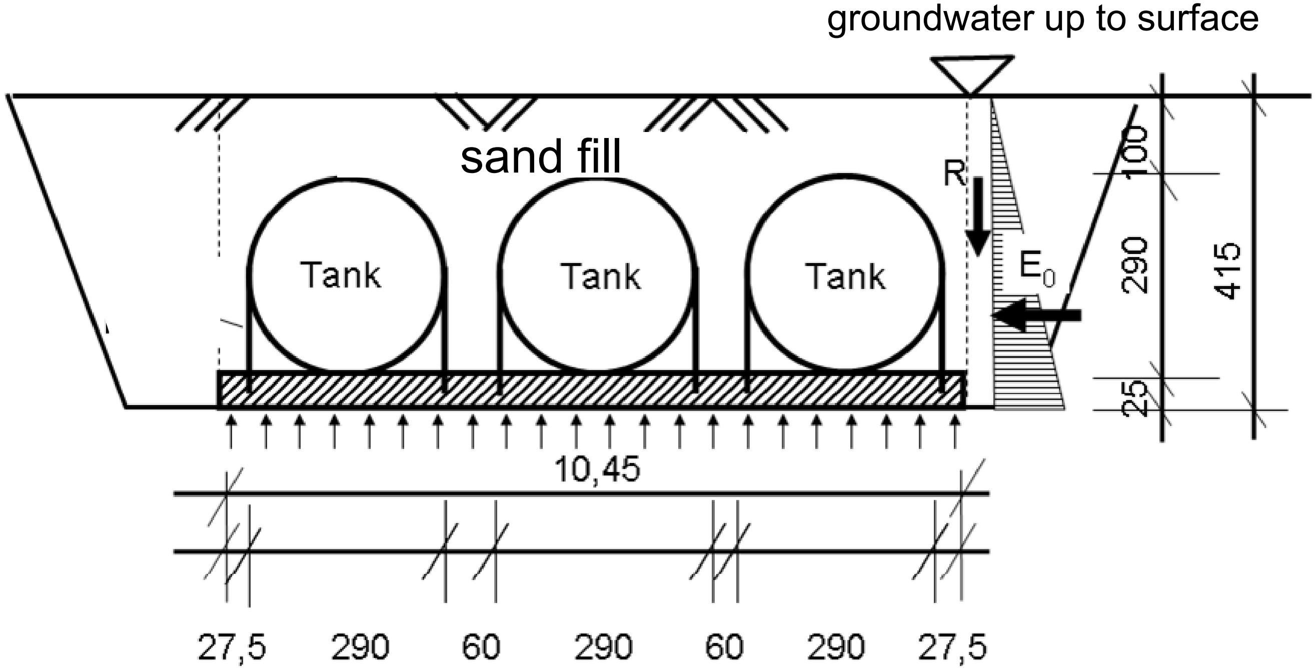



former times: Safety > 1,1 = dead weight / buoyancy

without sand fill of the tank‘s pit everything is easy:
- dead weight resulting from tanks and concrete slab
- buoyancy resulting from the volume of tanks and concrete slab

but how shall we count for the sandfill in the verification? :
- take dry unit weight to count for dead weight or effective unit weight under upflift?
- buoyancy resulting from total sand volume or only from the volume of the solid grains?

# Uplift-verification for tanks




Concept with partial safety factors:

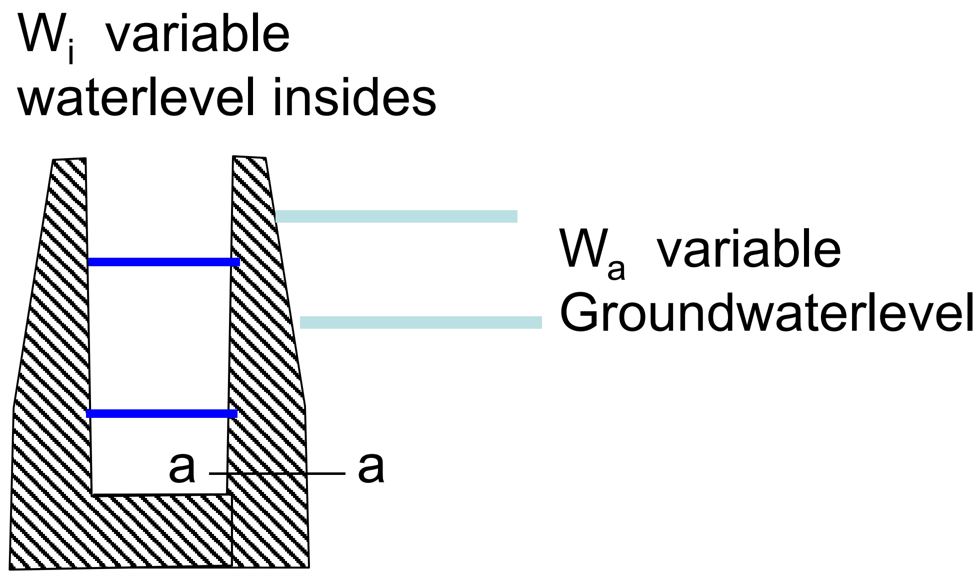
0,95 · stabilising actions > 1,05 · destabilising actions

Water pressure on the bottom side of the concrete slab is destabilising.

Stabilising are: the dead loads of the tanks, the concrete slab, the sand (take $G_{dry}$, because the displaced water flows away to the side) and the net volume of water in the pore-space on top of the concrete slab (n · V); additionally lateral friction R (both sides)

but the single-source-principle is violated $\gamma_{stb}$ (water above) ≠ $\gamma_{dst}$ ( water below)

# Waterpressures around a lock




design values for bending moment in a-a turning left and right:

- waterlevel insides with $\gamma_G$ or $\gamma_Q$ ?
- $\gamma_Q$ with max. waterlevel = 1,5 ?
- $\gamma_Q$ with min. waterlevel = 0 ?
- $\gamma_f$ for effects of Groundwater: 1,2 (Holland), 1,35 or 1,5 ?
- or additional waterhead on extreme groundwaterlevel ?

# Design situations defined in DIN 1054-100:2010

2.2 Design situations

A (4) The four design situations are defined as follows:

a) Design situation DS-P:
Persistent situations, which are according to usual conditions of usage of the structure are assigned to design situation DS-P.
Herein are considered permanent actions and regularly occuring variable actions during the time of function if the structure

b) Design situation DS-T:
Transient situations which relate to temporal confined conditions, i.e.

- construction conditions during fabrication of a structure,
- construction conditions related to an existing structure, for example during repair or as consequence of excavation or underpinnig works,
- building activities for transient purposes, for example slopes of excavation pits or constructions of pit linings, excluded special definitions for struts, anchors and micropiles

are assigned to design situation DS-T.
Design situation DS-T is also effectual, if besides regularly occuring variable actions of DS-P the occurence of a rare action, for example

- the occurence of an exceptional large action or
    - according to plan one time action

      is considered. Actions which are depending on each other count as a single action.

# Design situations defined in DIN 1054-100:2010

c) Design situation DS-A:

Accidental situations related to extraordinary conditions of the structure or its surrounding, for example fire or brand, explosion, impact, extreme high water level or failing of anchors, are assigned to design situation DS-A.
Besides the extraordinary conditions also permanent and regularly occuring variable actions as in design situations DS-P and DS-T are considered within this situation.

An extraordinary situation is also effectual, if at the same time several rare actions which are independent from each other, for example exceptional large actions or according to plan one time actions have to be considered.

If exceptionally two extraordinary actions are considered at the same time, then the partial factors $\gamma_G$ and $\gamma_Q$ may be reduced to 1,00.

d) Design situation DS-E:

Situations due to earthquake are assigned to design situation DS-E.

Notabene: Partial factors for actions, effects of actions and also resistances are dependent from the design situation, see next slides

**Tabelle A 2.1 — Teilsicherheitsbeiwerte $\gamma_F$[1] bzw. $\gamma_E$[2] für Einwirkungen und Beanspruchungen**

| Einwirkung bzw. Beanspruchung | Formelzeichen | Bemessungssituation | | |
|---|---|---|---|---|
| | | BS-P | BS-T | BS-A |
| **HYD und UPL: Grenzzustand des Versagens durch hydraulischen Grundbruch und Aufschwimmen** | | | | |
| Destabilisierende ständige Einwirkungen[a] | $\gamma_{G,dst}$ | 1,05 | 1,05 | 1,00 |
| Stabilisierende ständige Einwirkungen | $\gamma_{G,stb}$ | 0,95 | 0,95 | 0,95 |
| Destabilisierende veränderliche Einwirkungen | $\gamma_{Q,dst}$ | 1,50 | 1,30 | 1,00 |
| Stabilisierende veränderliche Einwirkungen | $\gamma_{Q,stb}$ | 0 | 0 | 0 |
| Strömungskraft bei günstigem Untergrund | $\gamma_H$ | 1,35 | 1,30 | 1,20 |
| Strömungskraft bei ungünstigem Untergrund | $\gamma_H$ | 1,80 | 1,60 | 1,35 |
| **STR und GEO-2: Grenzzustand des Versagens von Bauwerken, Bauteilen und Baugrund** | | | | |
| Beanspruchungen aus ständigen Einwirkungen allgemein[a] | $\gamma_G$ | 1,35 | 1,20 | 1,10 |
| Beanspruchungen aus günstigen ständigen Einwirkungen[b] | $\gamma_{G,inf}$ | 1,00 | 1,00 | 1,00 |
| Beanspruchungen aus ständigen Einwirkungen aus Erdruhedruck | $\gamma_{E0,G}$ | 1,20 | 1,10 | 1,00 |
| Beanspruchungen aus ungünstigen veränderlichen Einwirkungen | $\gamma_Q$ | 1,50 | 1,30 | 1,10 |
| Beanspruchungen aus günstigen veränderlichen Einwirkungen | $\gamma_Q$ | 0 | 0 | 0 |

**Tabelle A 2.3 — Teilsicherheitsbeiwerte $\gamma_R$[6] für Widerstände**

| Widerstand | Formelzeichen | Bemessungssituation | | |
|---|---|---|---|---|
| | | BS-P | BS-T | BS-A |
| **STR und GEO-2: Grenzzustand des Versagens von Bauwerken, Bauteilen und Baugrund** | | | | |
| Bodenwiderstände | | | | |
| — Erdwiderstand und Grundbruchwiderstand | $\gamma_{R,e}$, $\gamma_{R,v}$ | 1,40 | 1,30 | 1,20 |
| — Gleitwiderstand | $\gamma_{R,h}$ | 1,10 | 1,10 | 1,10 |
| Pfahlwiderstände aus statischen und dynamischen Pfahlprobebelastungen | | | | |
| — Fußwiderstand | $\gamma_b$ | 1,10 | 1,10 | 1,10 |
| — Mantelwiderstand (Druck) | $\gamma_s$ | 1,10 | 1,10 | 1,10 |
| — Gesamtwiderstand (Druck) | $\gamma_t$ | 1,10 | 1,10 | 1,10 |
| — Mantelwiderstand (Zug) | $\gamma_{s,t}$ | 1,15 | 1,15 | 1,15 |
| Pfahlwiderstände auf der Grundlage von Erfahrungswerten | | | | |
| — Druckpfähle | $\gamma_b$, $\gamma_s$, $\gamma_t$ | 1,40 | 1,40 | 1,40 |
| — Zugpfähle (nur in Ausnahmefällen) | $\gamma_{s,t}$ | 1,50 | 1,50 | 1,50 |
| Herausziehwiderstände | | | | |
| — Boden- bzw. Felsnägel | $\gamma_a$ | 1,40 | 1,30 | 1,20 |
| — Verpresskörper von Verpressankern | $\gamma_a$ | 1,10 | 1,10 | 1,10 |
| — Flexible Bewehrungselemente | $\gamma_a$ | 1,40 | 1,30 | 1,20 |
| **GEO-3: Grenzzustand des Versagens durch Verlust der Gesamtstandsicherheit** | | | | |