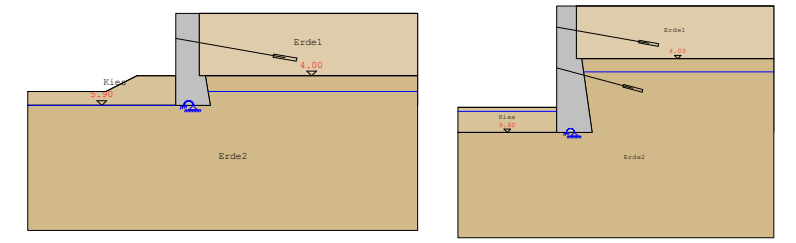
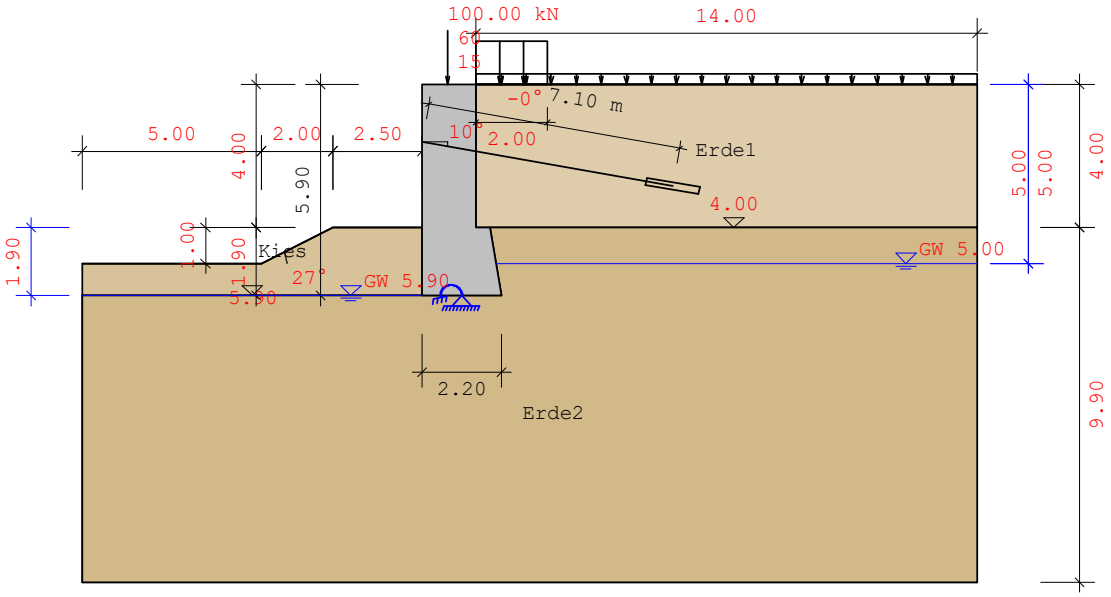
# PINWALLS Underpinning V:18.0 16052018

File: Beispiel_01
Project name:
Projektname

## Construction states A,B




## Construction state A




## Used standards:

DIN EN 1997-1, Design: DIN EN 1992-1-1

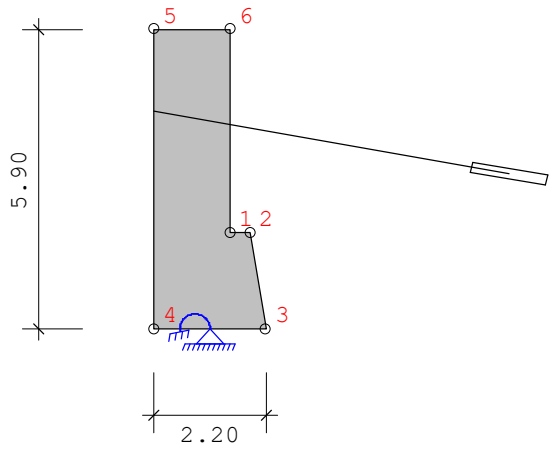
Partial safety factor for actions and loadings:

| Design situations: | BS-P(1q) | BS-T(2) | BS-A(3) |
|---|---|---|---|
| STR/GEO-2: Verification for the nominal limit states: | | | |
| permanent, general: | 1.35 | 1.20 | 1.10 |
| unfavorable variable: | 1.50 | 1.30 | 1.10 |
| permanent, earth pressure at rest: | 1.20 | 1.10 | 1.00 |
| EQU: Proof of equilibrium | | | |
| favorable, permanent: | 0.90 | 0.90 | 0.95 |
| unfavorable, permanent | 1.10 | 1.05 | 1.00 |
| favorable, variable: | 0.00 | 0.00 | 0.00 |
| unfavorable, variable: | 1.50 | 1.25 | 1.00 |
| GEO-3: Serviceability (Slip circle) | | | |
| Dead load: | 1.00 | 1.00 | 1.00 |
| unfavorable, variable: | 1.30 | 1.20 | 1.00 |

| | | | |
|---|---|---|---|
| STR,GEO-2: Resistances (slip, base failure, design) | | | |
| Earth resistance: | 1.40 | 1.30 | 1.20 |
| Slip resistance: | 1.10 | 1.10 | 1.10 |
| GEO-3: Geotechnical properties (Slip circle) | | | |
| tan phi': | 1.25 | 1.15 | 1.10 |
| Cohesion c': | 1.25 | 1.15 | 1.10 |

# Printout of the input:

## Wall geometry:




| No. | x [m] | z [m] |
|---|---|---|
| 1 | 0.000 | 4.000 |
| 2 | 0.400 | 4.000 |
| 3 | 0.700 | 5.900 |
| 4 | -1.500 | 5.900 |
| 5 | -1.500 | 0.000 |
| 6 | 0.000 | 0.000 |

## Supports:

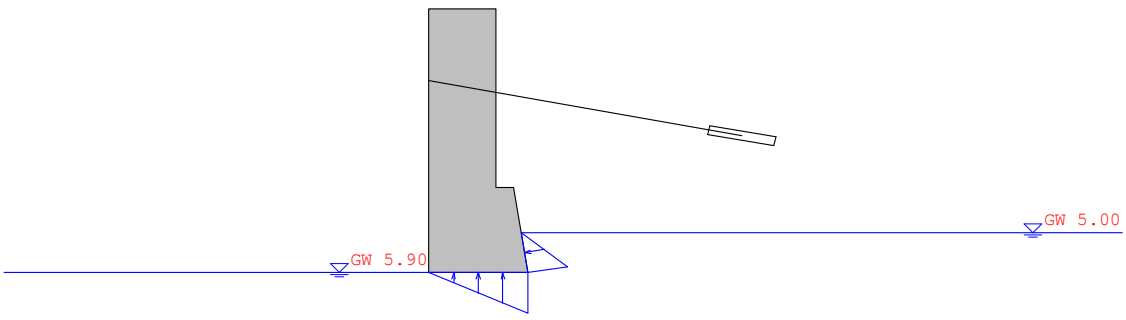
| zA[m] | Inclination | Min. length[m] | Spring[kN/m] |
|---|---|---|---|
| 1.60 | 10.00 | 7.10 | --- |

## Support conditions:

**Support top:** Support free movable

**Support bottom:** Support with torsion spring
Torsion spring constant = 100000 kN/m

## Groundwater:




Water pressure at wall

Groundwater right: 5.00 m
Groundwater left: 5.90 m

**Single load acting on the top of wall:**

| BS | x[m] | z [m] | Angle of load[ | P[kN/m] | Frictio |
|---|---|---|---|---|---|
| BS-P(1g) | -0.80 | 0.00 | 270.00 | 100.00 | Yes |

BS-P(1g) Total load on top of the wall: 100 kN/m

**Soil layers:**

| Name | phi[°] | delta | Cohesion | gamma | gamma' | Es |
|---|---|---|---|---|---|---|
| Erde1 | 30.00 | 20.00 | 0.00 | 20.00 | 10.00 | 10000 |
| Kies | 30.00 | 0.00 | 0.00 | 20.00 | 10.00 | 0 |
| Erde2 | 25.00 | 13.00 | 0.00 | 18.00 | 11.00 | 10000 |

**Loads:**

Units ... Strip load [kN/m2], Line load [kN/m]

| Load type | BS | x1 [m] | z1 [m] | b [m] | q1 | q2 | Redistri. | ph [kN/m] | S' [kN/m] |
|---|---|---|---|---|---|---|---|---|---|
| Strip | BS-P(1g) | 0.00 | 0.00 | --- | 15.00 | 15.00 | No | - | - |
| Block | BS-P(1g) | 0.00 | 0.00 | 2.00 | 60.00 | 60.00 | Constant | - | - |

# Results:

## Earth pressure:

### Earth pressure options:

```
 Load calculation iterative:          No
 Consider cohesion          acc. to classical approach
     (kach=2*(sqrt(kah))*cos(delta)
 Calculation of                      active earth pressure
 Considering of earth resistance?    with 50%
```

### Earth pressure coefficient:

| No. | Name | φ[°] | δ[°] | α[°] | β[°] |
|---|---|---|---|---|---|
| 1 | Erde1 | 30.00 | 20.00 | 0.00 | 0.00 |
| 2 | Erde2 | 25.00 | 13.00 | -8.97 | 0.00 |
| 3 | Erde2 | 25.00 | 13.00 | 0.00 | 0.00 |
| 4 | Kies | 30.00 | 0.00 | 0.00 | 0.00 |
| 5 | Kies | 30.00 | 0.00 | 0.00 | -26.57 |

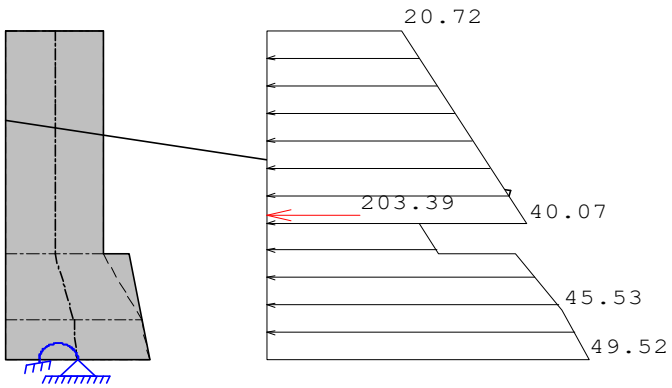
| No. | Kah | Kach | K0h | Kph | Kpch |
|---|---|---|---|---|---|
| 1 | 0.279 | --- | --- | --- | --- |
| 2 | 0.403 | --- | --- | --- | --- |
| 3 | 0.357 | --- | --- | --- | --- |
| 4 | --- | --- | --- | 3.000 | --- |
| 5 | --- | --- | --- | 1.124 | --- |

### Earth pressure redistribution:

```
 Distribution:                              trapezoidal:
 Consider loads:          from g and p
 Levels of z1 and z2 of the redistribution:
   z1 and z2 are moved to the anchor height levels.
```

### Characteristical horizontal rate of the earth pressure (not redistributed):

### BS-P(1g):



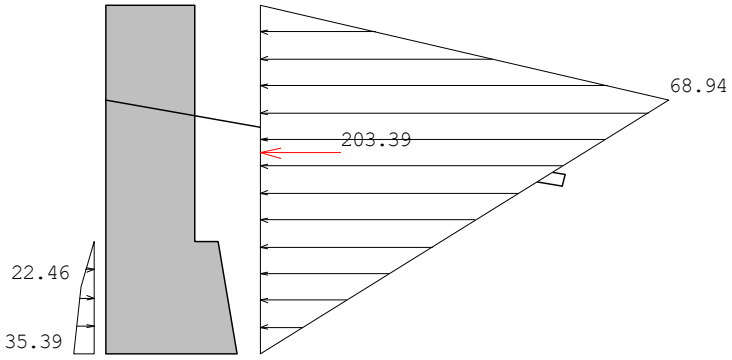

| z-Koo[m] | eh[kN/m2] |
|---|---|
| 0.000 | 0.000 |
| 0.000 | 20.718 |
| 3.464 | 40.074 |
| 3.464 | 23.547 |

| | |
|---|---|
| 4.000 | 26.541 |
| 4.000 | 38.276 |
| 5.000 | 45.528 |
| 5.900 | 49.516 |
| 5.900 | 0.000 |

**Characteristical horizontal rate of the earth pressure (redistributed):**

| z-Koo[m] | eh[kN/m2] |
|---|---|
| 4.000 | 0.000 |
| 4.749 | 22.457 |
| 5.900 | 35.395 |
| 5.900 | 0.000 |

**BS-P(1g):**




| z-Koo[m] | eh[kN/m2] |
|---|---|
| 0.000 | 0.000 |
| 1.600 | 68.945 |
| 5.900 | 0.000 |

**Loading of beam axis:**

Line loads: Excavation state 'A'

| Beam no. | z-Koo[m] | Ph[kN/m²] | Pv[kN/m²] | M[kNm/m] |
|---|---|---|---|---|
| 0 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 1.600 | 68.945 | 25.094 | 0.000 |
| 1 | 1.600 | 68.945 | 25.094 | 0.000 |
| | 1.732 | 66.824 | 24.322 | 0.000 |
| 2 | 1.732 | 66.824 | 24.322 | 0.000 |
| | 4.000 | 30.464 | 11.088 | 0.000 |
| 3 | 4.000 | 30.464 | 12.291 | 0.000 |
| | 4.749 | -3.995 | 7.449 | 0.000 |
| 4 | 4.749 | -3.995 | 7.449 | 0.000 |
| | 5.000 | -10.852 | 5.822 | 0.000 |
| 5 | 5.000 | -10.852 | 5.822 | 0.000 |
| | 5.169 | -13.795 | 4.991 | 0.000 |
| 6 | 5.169 | -13.795 | 4.991 | 0.000 |
| | 5.900 | -26.505 | 1.404 | 0.000 |

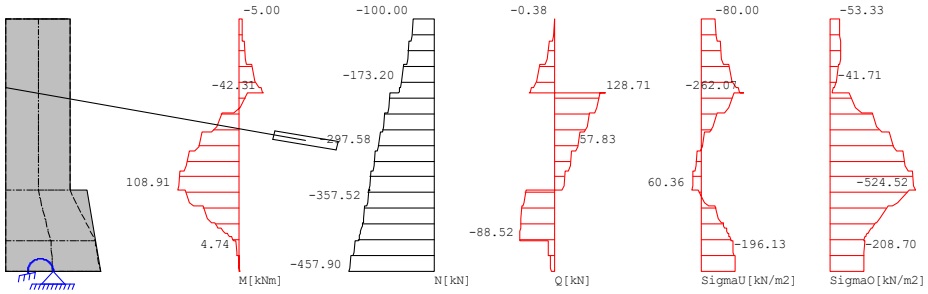
Point loads: Excavation state 'A'

| Beam no. | z-Koo[m] | Ph[kN/m] | Pv[kN/m] | M[kNm/m] |
|---|---|---|---|---|
| | 5.900 | 0.000 | -9.900 | -0.000 |

**Characteristic stress resultants:**

All sections refer to 1m wall width.

**BS-P(1g):**




| Beam no. | z-Koo[m] | M[kNm] | N[kN] | Q[kN] | Px[kN/m2] |
|---|---|---|---|---|---|
| 1 | 0.000 | -5.000 | -100.000 | 0.000 | 0.000 |
| 1 | 0.533 | -6.090 | -122.715 | -6.129 | 0.000 |
| 1 | 0.933 | -10.839 | -142.678 | -18.768 | 0.000 |
| 1 | 1.067 | -22.024 | -165.151 | -38.303 | 0.000 |
| 1 | 1.600 | -34.417 | -181.527 | -55.156 | 0.000 |
| 2 | 1.600 | -34.417 | -181.527 | -55.156 | 0.000 |
| 2 | 1.600 | -38.214 | -185.714 | -59.680 | 0.000 |
| 2 | 1.732 | -42.307 | -189.874 | -64.133 | 0.000 |
| 3 | 1.732 | -42.307 | -223.878 | 128.711 | 0.000 |
| 3 | 2.186 | 20.411 | -258.504 | 93.402 | 0.000 |
| 3 | 2.639 | 64.573 | -291.254 | 63.247 | 0.000 |
| 3 | 3.433 | 93.100 | -322.129 | 38.246 | 0.000 |
| 3 | 4.000 | 108.913 | -351.128 | 18.398 | 0.000 |
| 4 | 4.000 | 108.913 | -345.106 | -67.313 | 0.000 |
| 4 | 4.281 | 87.900 | -357.521 | -77.361 | 0.000 |
| 4 | 4.374 | 72.489 | -366.555 | -82.173 | 0.000 |
| 4 | 4.749 | 47.996 | -381.243 | -86.558 | 0.000 |
| 5 | 4.749 | 47.996 | -381.243 | -86.558 | 0.000 |
| 5 | 4.843 | 39.543 | -386.462 | -87.350 | 0.000 |
| 5 | 4.874 | 33.870 | -390.005 | -87.755 | 0.000 |
| 5 | 5.000 | 25.318 | -395.413 | -88.177 | 0.000 |
| 6 | 5.000 | 25.318 | -395.413 | -88.177 | 0.000 |
| 6 | 5.063 | 19.544 | -399.116 | -88.357 | 0.000 |
| 6 | 5.085 | 15.689 | -401.610 | -88.443 | 0.000 |
| 6 | 5.169 | 9.900 | -405.392 | -88.522 | 0.000 |
| 7 | 5.169 | 9.900 | -414.451 | -20.238 | 0.000 |

| | | | | | |
|---|---|---|---|---|---|
| 7 | 5.443 | 4.742 | -430.713 | -17.075 | 0.000 |
| 7 | 5.535 | 1.864 | -441.575 | -14.240 | 0.000 |
| 7 | 5.900 | -1.346 | -457.900 | -8.897 | 0.000 |

**Characteristic cross-section stresses:**

**BS-P(1g):**

| Beam no. | z-Koo[m] | SigmaU[kN/m2] | SigmaO[kN/m2] |
|---|---|---|---|
| 1 | 0.000 | -80.000 | -53.333 |
| 1 | 0.533 | -98.049 | -65.571 |
| 1 | 0.933 | -124.023 | -66.215 |
| 1 | 1.067 | -168.830 | -51.371 |
| 1 | 1.600 | -212.796 | -29.241 |
| 2 | 1.600 | -212.796 | -29.241 |
| 2 | 1.600 | -225.712 | -21.906 |
| 2 | 1.732 | -239.403 | -13.763 |
| 3 | 1.732 | -262.072 | -36.432 |
| 3 | 2.186 | -117.906 | -226.766 |
| 3 | 2.639 | -21.974 | -366.365 |
| 3 | 3.433 | 33.514 | -463.019 |
| 3 | 4.000 | 56.350 | -524.520 |
| 4 | 4.000 | 60.364 | -520.506 |
| 4 | 4.281 | -21.948 | -413.958 |
| 4 | 4.374 | -64.465 | -370.064 |
| 4 | 4.749 | -121.431 | -285.384 |
| 5 | 4.749 | -121.431 | -285.384 |
| 5 | 4.843 | -136.868 | -265.398 |
| 5 | 4.874 | -147.175 | -255.485 |
| 5 | 5.000 | -159.729 | -235.684 |
| 6 | 5.000 | -159.729 | -235.684 |
| 6 | 5.063 | -168.034 | -224.849 |
| 6 | 5.085 | -174.077 | -219.214 |
| 6 | 5.169 | -180.799 | -208.138 |
| 7 | 5.169 | -185.145 | -212.483 |
| 7 | 5.443 | -196.130 | -208.697 |
| 7 | 5.535 | -203.685 | -208.558 |
| 7 | 5.900 | -209.806 | -206.468 |

**Deformation due to characteristic load:**

**BS-P(1g):**

| x-Coo[m] | z-Koo[m] | dx [mm] | dz [mm] |
|---|---|---|---|
| -0.75 | 0.00 | 0.00704 | 0.04102 |
| -0.75 | 0.53 | 0.00323 | 0.03956 |
| -0.75 | 1.07 | -0.00083 | 0.03778 |
| -0.75 | 1.60 | -0.00544 | 0.03561 |
| -0.75 | 1.60 | -0.00544 | 0.03561 |
| -0.75 | 1.73 | -0.00675 | 0.03500 |
| -0.75 | 1.73 | -0.00675 | 0.03500 |
| -0.75 | 2.19 | -0.01171 | 0.03235 |
| -0.75 | 2.64 | -0.01645 | 0.02939 |
| -0.75 | 3.09 | -0.01989 | 0.02614 |
| -0.75 | 3.55 | -0.02125 | 0.02262 |
| -0.75 | 4.00 | -0.02000 | 0.01883 |
| -0.75 | 4.00 | -0.02000 | 0.01883 |
| -0.66 | 4.37 | -0.01766 | 0.01489 |
| -0.56 | 4.75 | -0.01407 | 0.01083 |
| -0.56 | 4.75 | -0.01407 | 0.01083 |
| -0.53 | 4.87 | -0.01271 | 0.00947 |
| -0.50 | 5.00 | -0.01131 | 0.00810 |
| -0.50 | 5.00 | -0.01131 | 0.00810 |
| -0.48 | 5.08 | -0.01035 | 0.00719 |
| -0.46 | 5.17 | -0.00938 | 0.00628 |
| -0.46 | 5.17 | -0.00938 | 0.00628 |

| | | | |
|---|---|---|---|
| -0.43 | 5.53 | -0.00470 | 0.00317 |
| -0.40 | 5.90 | 0.00000 | 0.00000 |

**Support reactions, characteristic:**

**Load case 1(g):**

Support reaction top: Support free movable
Support reaction bottom: Fx: 27.17 kN/m Fz: 447.28 kN/m M: -1.35 kNm/m

**Characteristic anchor and supporting forces:**

| Anchor 1 | z-Koo[m] | Force[kN/m] |
|---|---|---|
| BS-P(1g) | 1.60 | 195.82 |

**ULS and SLS design:**

| | |
|---|---|
| Standard: | DIN EN 1992-1-1 |
| Concrete wall: | C12/15 |
| Reinforcement: | B500S |
| Concrete weight: | 25.00 kN/m3 |
| Reinforcement center distance hb, wall: | 5.00 cm |
| Reinforcement center distance ht, wall: | 5.00 cm |

**Design options:**

```
 Consider earth resistance:                                    Yes
 Consider load on excavation side:                             No
 Consider earth pressure due to soil weight:                 Yes
 Consider loadings right:                                                Yes
 Consider user-defined earth pressures:                          No
 Consider hydrostatic pressure due to groundwate on right sider:          Yes
 Consider hydrostatic pressure due to groundwater:             Yes
 Consider user-defined loading due to water on right side:      No
 Consider wall weight:                               Yes
 Consider vertical parts of the earth pressures:                   Yes
 Consider moment parts of the earth pressure:                   No

 Requirements class:                    Class E
 Structural member:                     Slab
 Structure type:
Building construction/Building construction
 Exposure classes:
   XC4: Alternating wet and dry
   XD2: Wet, rarely dry
   XS1: Saline air but no contact to sea water

 ULS design:
   Minimum longitudinal reinforcement   No
   Min. shear force reinforcement       No
   Design of the wall as compression memNo

 SLS design:
   Final crack - direct crack width computation

   Minimum reinforcement: Individual craYes
   Calculated crack width               0.30 mm
   Limiting diameter top                16.00 mm
   Limiting diameter bottom             16.00 mm
```

**Material coefficients:**

| | permanent/transient | Accidental | Coefficient acc. for |
|---|---|---|---|
| Concrete | 1.50 | 1.20 | 0.85 |
| Reinforcemen | 1.15 | 1.00 | |

**Design sections:**

relating to 1m wall width

| No. | xm[m] | zm[m] | d[cm] |
|---|---|---|---|
| a-a | -0.75 | 1.03 | 150.00 |
| b-b | -0.75 | 2.63 | 150.00 |
| c-c | -0.65 | 4.62 | 175.58 |

**Design sections: BS-P(1)**

```
 γG       ... Partial safety factor -  GZ1B permanent actions
 γQ       ... Partial safety factor -  GZ1B variable actions
 Mkg      ... Characteristical permanent moment
 Mkq      ... Characteristical variable moment
 Md       ... Design moment Md
 Nkg      ... Characteristical permanent normal force
 Nkq      ... Characteristical variable normal force
 Nd       ... Design normal force
 Qkg      ... Characteristical permanent shear force
 Qkq      ... Characteristical variable shear force
 Qd       ... Design shear force
 Md = Mkg*γG + Mkq*γQ
 Nd = Nkg*γG + Nkq*γQ
```

```
 Qd = Qkg*γG + Qkq*γQ

 psi1         ... Combination coefficient for frequent loading
 psi2         ... Combination coefficient for quasi, permanent loading
 M,Q,N_rare   ... characteristic stress resultants, rare loading
 M,Q,N_freq   ... characteristic stress resultants, frequent loading
 M,Q,N_quasi  ... characteristic stress resultants, quasi, permanent loading

  M_rare    = Mkg+ Mkq
  M_freq    = Mkg+ Mkq*psi1
  M_quasi   = Mkg+ Mkq*psi2


 αc        ... Solidity coefficient = 0.81
 fck       ... Characteristical cylinder strength of the concrete
 γc        ... Partial safety factor of the plain concrete γc=γ
c*1.2= 1.5*1.2=1.80
 αD        ... Reduction factor due to load transfer=0.85
 NRd       ... Structure resistance normal force
 MRd       ... Structure resistance bending moment
```

**Stress resultants due to ULS**

| No. | γG | γQ | Mkg | Mkq | Md | Nkg | Nkq | Nd |
|---|---|---|---|---|---|---|---|---|
| a-a | 1.35 | 1.50 | -12.92 | 0.00 | -17.45 | -147.91 | 0.00 | -199.67 |
| b-b | 1.35 | 1.50 | 48.22 | 0.00 | 65.10 | -277.84 | 0.00 | -375.08 |
| c-c | 1.35 | 1.50 | 57.32 | 0.00 | 77.39 | -375.58 | 0.00 | -507.03 |

| No. | Qkg | Qkq | Qd |
|---|---|---|---|
| a-a | -22.93 | 0.00 | -30.96 |
| b-b | 75.19 | 0.00 | 101.50 |
| c-c | -85.29 | 0.00 | -115.14 |

**Stress resultants SLS**

| No. | psi1 | psi2 | γG | γQ | M,rare | M,freq | M,quasi |
|---|---|---|---|---|---|---|---|
| a-a | 0.75 | 0.20 | 1.35 | 1.50 | -12.92 | -12.92 | -12.92 |
| b-b | 0.75 | 0.20 | 1.35 | 1.50 | 48.22 | 48.22 | 48.22 |
| c-c | 0.75 | 0.20 | 1.35 | 1.50 | 57.32 | 57.32 | 57.32 |

| No. | N,rare | N,freq | N,quasi | Q,rare | Q,freq | Q,quasi |
|---|---|---|---|---|---|---|
| a-a | -147.91 | -147.91 | -147.91 | -22.93 | -22.93 | -22.93 |
| b-b | -277.84 | -277.84 | -277.84 | 75.19 | 75.19 | 75.19 |
| c-c | -375.58 | -375.58 | -375.58 | -85.29 | -85.29 | -85.29 |

**Necessary longitudinal reinforcement due to ULS and SLS:**

aso [cm2] ... Required longitudinal reinforcement top
asu [cm2] ... Required longitudinal reinforcement bottom
epsz[o/oo] ... Steel strain
epsd[o/oo] ... Concrete compressive strain
zi[m] ... Inner lever arm

| No. | aso | asu | epsz | epsd | zi |
|---|---|---|---|---|---|
| a-a | 0.00 | 0.00 | -0.28 | -3.29 | 1.30 |
| b-b | 0.00 | 0.00 | 0.29 | -3.50 | 0.87 |
| c-c | 0.00 | 0.00 | 0.02 | -3.50 | 1.53 |

**Necessary shear reinforcement due to ULS and SLS:**

ass[cm2/m] ... Required shear reinforcement, under 90°
VRdct[kN] ... Shear force capacity of the bending reinforcement
VRdmax[kN] ... Shear force capacity of the compressive strut
vsd [kN] ... Decisive shear force
VRd,s[kN] ... Shear force capacity of the shear reinforcement component
rho[%] ... Percentage of reinforcement longitudinal
theta[°] ... Compression strut inclination asccording to DAfStb/H.425

| No. | ass | vsd | VRdct | VRdmax | VRd,s | rho | theta |
|---|---|---|---|---|---|---|---|
| a-a | 0.00 | 30.96 | 224.83 | 3327.75 | 0.00 | 0.000 | 45.0 |
| b-b | 0.00 | 101.50 | 245.18 | 2228.70 | 0.00 | 0.000 | 45.0 |
| c-c | 0.00 | 115.14 | 288.88 | 3914.25 | 0.00 | 0.000 | 45.0 |

**Design of the plain concrete in STR/GEO-2:**

**BS-P(1g):**

**Design section a-a:**

Md = Mgk*γG+Mpk*γQ= -12.92*1.35+0.00*1.50=-17.45 kNm
Nd = Ngk*γG+Npk*γQ= -147.91*1.35+0.00*1.50=-199.67 kN
e = Md/Nd = -17.45/-199.67 = 0.0874 m
e/h = 0.09/1.50 = 0.05826
0.0 <= e/h <= 0.084 ... Uncracked, over-pressed cross-section
k = αc + (1-αc/(e/h ungerissen) * (0.084-e/h) = 0.81+ (1-0.81)/0.084) * 0.084-0.0583 = 0.8682
fcd = alfa_cc* fck/γC =0.85* 12000.00/1.50= 6800.00 kN/m2
NRd = k*b*h*fcd = 0.8682*1.00*1.50*6800.00 = 8855.93 kN
MRd = NRd * Md/Nd = 8855.93*-17.45/-199.67 = 773.88 kNm

**NRd>Nd und MRd>Md ... Verification complied**

### Design section b-b:

Md = Mgk*γG+Mpk*γQ= 48.22*1.35+0.00*1.50=65.10 kNm
Nd = Ngk*γG+Npk*γQ= -277.84*1.35+0.00*1.50=-375.08 kN
e = Md/Nd = 65.10/-375.08 = 0.1736 m
e/h = 0.17/1.50 = 0.11571
0.084 < e/h <=0.4 ... Cracked cross-section in still allowable range.
psi = (0.5- e/h)/ 0.416 = 0.92378 k = psi*αc = 0.9238*0.810 = 0.7483
fcd = alfa_cc* fck/γC =0.85* 12000.00/1.50= 6800.00 kN/m2
NRd = k*b*h*fcd = 0.7483*1.00*1.50*6800.00 = 7632.27 kN
MRd = NRd * Md/Nd = 7632.27*65.10/-375.08 = 1324.67 kNm
**NRd>Nd und MRd>Md ... Verification complied**

### Design section c-c:

Md = Mgk*γG+Mpk*γQ= 57.32*1.35+0.00*1.50=77.39 kNm
Nd = Ngk*γG+Npk*γQ= -375.58*1.35+0.00*1.50=-507.03 kN
e = Md/Nd = 77.39/-507.03 = 0.1526 m
e/h = 0.15/1.76 = 0.08692
0.084 < e/h <=0.4 ... Cracked cross-section in still allowable range.
psi = (0.5- e/h)/ 0.416 = 0.99297 k = psi*αc = 0.9930*0.810 = 0.8043
fcd = alfa_cc* fck/γC =0.85* 12000.00/1.50= 6800.00 kN/m2
NRd = k*b*h*fcd = 0.8043*1.00*1.76*6800.00 = 9603.11 kN
MRd = NRd * Md/Nd = 9603.11*77.39/-507.03 = 1465.66 kNm
**NRd>Nd und MRd>Md ... Verification complied**

**Soil mechanic analysis of the overall stability:**
relating to 1m wall width

**Bottom pressure in GEO-2:**

```
Resultant force of foundation joint :
   BS      Rk      Rvk,g    Rhk,g    Rvk,q    Rhk,q   gamma_g  gamma_q    Rvd      Rhd      Rd
-------------------------------------------------------------------------------------------------
BS-P(1g)  448.10   447.28   -27.17     0.00     0.00     1.35     1.50   603.83   -36.68   604.94

 Embedment depth:                    1.90 m
 User-defined admissible stress:     Yes
 reduced width b'                b'= 2* (b/2- e)   e...Eccentricity

   BS     b'[m]  Rvd[kN]    Rvk,g     Rvk,q    exisσ,d    admσ,d
 ------------------------------------------------------------------
BS-P(1g)   2.19    603.83    447.28      0.00    275.22    300.00     fulfilled
```

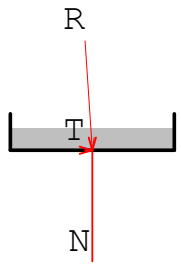
**Lateral buckling analysis for EQU, permanent loads**

```
 Length of the the foundation bottom edge b:   2.200 m
 Admissible eccentricity for dead load b/6:    0.367 m

 Rk [kN]   ... Resulting characteristical loading
 Asohl [%] ... Overpressed floor level

    BS        Rk[kN]   exis.e[m]  adm.e[m]   Abase[%]  Verifi. complied
 ------------------------------------------------------------------------
 BS-P(1g)      448.10      0.00       0.37      100.00         Yes
```

**Slip verification by GEO-2:**




```
  Sliding safety:

Resultant force of foundation joint (without contribution of the passive earth
pressure):
   BS      Rk      Rvk,g    Rhk,g    Rvk,q    Rhk,q
-------------------------------------------------------
BS-P(1g)  448.60   448.54     7.41     0.00     0.00

 floor level friction coefficient:                    seated equal to phi
 Consider earth resistance:              with 50%
 weighted phi of the surrounding soil layer:  25.00 °
 Inclination of floor level:                            0.00 °

 Ep[kN]   ... Earth resistance without reduction
 Epk[kN]  ... Characteristical, mobilized value of the earth resistance
 γEpk     ... Partial safety factor - earth resistance
 Epd[kN]  ... Design value of earth resistance
```

```
Rtd[kN]  ... Design value of the sliding resistance
Rtk[kN]  ... Characteristical sliding resistance
γGl      ... Partial safety factor - limit state GZ1B

Nk[kN]   ... Vertical acting component of the characteristical stress
δSk[°]   ... Chara. value of the angle of skin friction in the floor level

Td[kN]   ... Design value of the stress parallel to the floor level
TGk[kN]  ... Due to permanent loads
TQk[kN]  ... Due to live loads
γG       ... Partial safety factor - permanent actions GZ1B
γE0g     ... Partial safety factor - earth pressure at rest GZ1B
γQ       ... Partial safety factor - unfavorable variable actions GZ1B
```

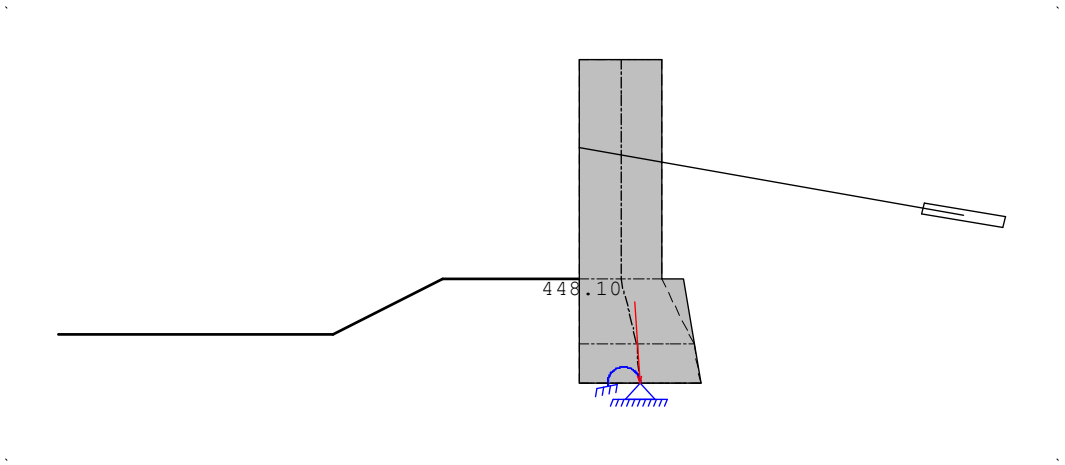
**BS-P(1g):**

```
Epk = Ep*0.50= 83.42*0.50 = 41.71 kN
Epk>Tk = 41.71>7.41  ... Epk=Tk= 7.41
Epd = Epk/γEp = 7.41/1.40 = 5.30 kN
Rtk = Nk*tanδSk = 448.54*tan(25.00°) = 209.16 kN
Rtd = Rtk/γGl = 209.16/1.10 = 190.14 kN
Td = TGk*γG + TQk*γQ = 7.41*1.35 + 0.00*1.50 = 10.01 kN
Td <= Rtd + Epd      10.01<=190.14+5.30
... Analysis fulfilled BS-P(1g)
```

**Base failure analysis by GEO-2:**

Resultant force of foundation joint (without contribution of the passive earth pressure):

| BS | Rk | Rvk,g | Rhk,g | Rvk,q | Rhk,q | gamma_g | gamma_q | Rvd | Rhd | Rd |
|---|---|---|---|---|---|---|---|---|---|---|
| BS-P(1g) | 448.60 | 448.54 | 7.41 | 0.00 | 0.00 | 1.35 | 1.50 | 605.53 | 10.01 | 605.61 |




Fracture body, LC 1(g)

**Base failure resistance formula:**

Rnk =a'*b'* [γ2*b'*Nb + (γ1*d+q) *Nd + c*Nc] ... DIN 4017

A strip foundation is assumed.
b' = b-2eb

Nb = Nb0 * νb * ib * λb * ξb
Nd = Nd0 * νd * id * λd * ξd
Nc = Nc0 * νc * ic * λc * ξc

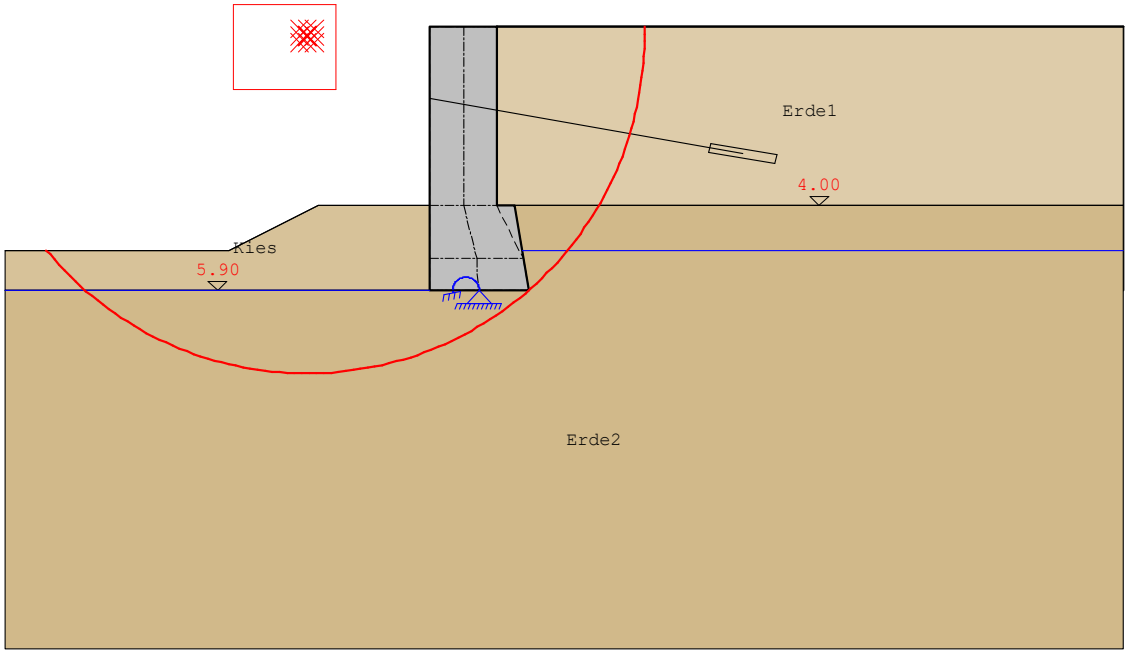
Ground slope at excavation side: 26.57 °
Inclination of floor level: 0.00 °

Nk ... Characteristical stress vertical to the foundation floor
Tk ... Characteristical stress parallel to the foundation floor
delta ... Load inclination tan(delta)= Tk/Nk
Rnk ... Characteristical base failure resistance
Rnd ... Design value of the base failure resistance = Rnk / Safety

---

System 'A' LC 1(g) Abort base failure System 'A' LC 1(g): The angle of repose beta=26.57° is greater then phi=25.00°.

**Slip circle analysis by GEO-3:**




Slip circle with minimum safety

Number of examined circles: 319
Grid spacing of the center of circles: x:0.16 m z:0.15 m

**Relevant slip circle:**

| BS | x-Coo[m] | z-Koo[m] | Radius[m] | Rd | Ed | Rd/Ed | fulfill |
|---|---|---|---|---|---|---|---|
| BS-P(1g) | -4.25 | 0.21 | 7.54 | 408.81 | 484.92 | 0.84 | No |

**Settlement analysis in SLS**

Settlement in the left (A) and right point (B) at the bottom edge of the wall.
A gaping joint exists, if the resultant of the base pressure is within the core.

User-def. embedment depth: None calculated depth: 1.90 m
set limiting depth: None calculated depth: 4.40 m

| BS | Point A[cm] | Point B[cm] | Gaping joint: |
|---|---|---|---|

| | | | |
|---|---|---|---|
| BS-P(1g) | 2.84 | 3.00 | not existing |

## Overview of the analyses

### Overview safety verifications overall stability

**Bottom pressure in GEO-2:**

| BS | b'[m] | Rvd[kN] | Rvk,g | Rvk,q | exisσ,d | admσ,d | |
|---|---|---|---|---|---|---|---|
| BS-P(1g) | 2.19 | 603.83 | 447.28 | 0.00 | 275.22 | 300.00 | fulfilled |

**Lateral buckling analysis for EQU, permanent loads**

| BS | Rk[kN] | exis.e[m] | adm.e[m] | Abase[%] | Verifi. complied |
|---|---|---|---|---|---|
| BS-P(1g) | 448.10 | 0.00 | 0.37 | 100.00 | Yes |

**Slip verification by GEO-2:**

Td <= Rtd + Epd 10.01<=190.14+5.30 ... Analysis fulfilled BS-P(1g)

**Base failure analysis by GEO-2:**

System 'A' LC 1(g) Abort base failure System 'A' LC 1(g): The angle of repose beta=26.57° is greater then phi=25.00°.

**Slip circle analysis by GEO-3:**

Relevant slip circle:

| BS | x-Coo[m] | z-Koo[m] | Radius[m] | Rd | Ed | Rd/Ed | fulfill |
|---|---|---|---|---|---|---|---|
| BS-P(1g) | -4.25 | 0.21 | 7.54 | 408.81 | 484.92 | 0.84 | No |

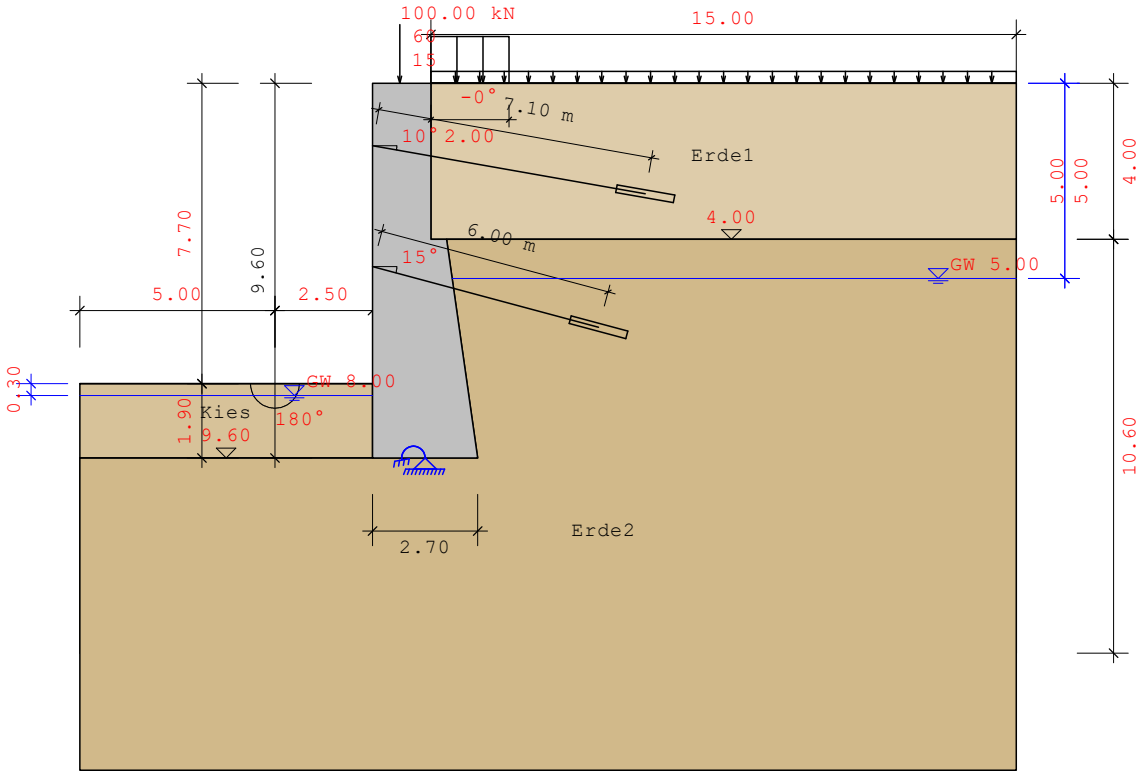
**Necessary longitudinal reinforcement due to ULS and SLS: (LF BS-P(1))**

| No. | aso | asu | epsz | epsd | zi |
|---|---|---|---|---|---|
| a-a | 0.00 | 0.00 | -0.28 | -3.29 | 1.30 |
| b-b | 0.00 | 0.00 | 0.29 | -3.50 | 0.87 |
| c-c | 0.00 | 0.00 | 0.02 | -3.50 | 1.53 |

**Necessary shear reinforcement due to ULS and SLS: (LF BS-P(1))**

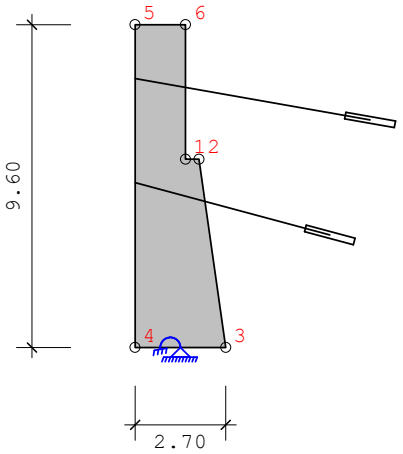
| No. | ass | vsd | VRdct | VRdmax | VRd,s | rho | theta |
|---|---|---|---|---|---|---|---|
| a-a | 0.00 | 30.96 | 224.83 | 3327.75 | 0.00 | 0.000 | 45.0 |
| b-b | 0.00 | 101.50 | 245.18 | 2228.70 | 0.00 | 0.000 | 45.0 |
| c-c | 0.00 | 115.14 | 288.88 | 3914.25 | 0.00 | 0.000 | 45.0 |

# Construction state B


100.00 kN
15.00
-0°
7.10 m
10°
2.00
Erde1
4.00
6.00 m
15°
GW 5.00
5.00
5.00
4.00
7.70
9.60
5.00
2.50
0.30
GW 8.00
Kies
180°
1.90
9.60
10.60
2.70
Erde2

# Printout of the input:

## Wall geometry:




| No. | x [m] | z [m] |
|---|---|---|
| 1 | 0.000 | 4.000 |
| 2 | 0.400 | 4.000 |
| 3 | 1.200 | 9.600 |
| 4 | -1.500 | 9.600 |
| 5 | -1.500 | 0.000 |
| 6 | 0.000 | 0.000 |

## Supports:

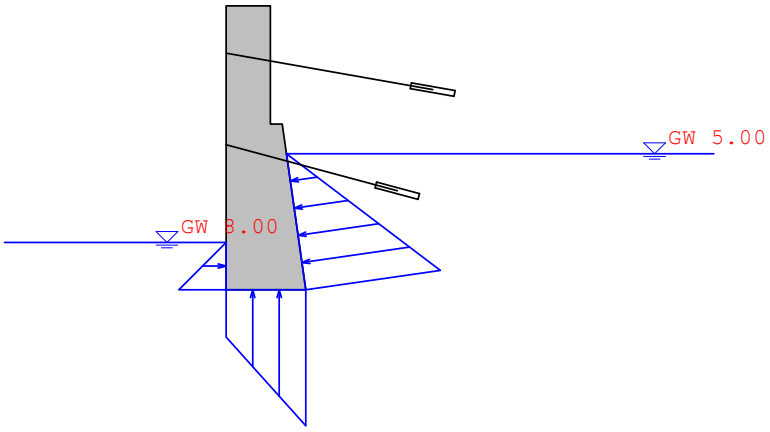
| zA[m] | Inclination | Min. length[m] | Spring[kN/m] |
|---|---|---|---|
| 1.60 | 10.00 | 7.10 | --- |
| 4.70 | 15.00 | 6.00 | --- |

## Support conditions:

**Support top:** Support free movable

**Support bottom:** Support with torsion spring
Torsion spring constant = 200000 kN/m

## Groundwater:




Water pressure at wall

Groundwater right: 5.00 m
Groundwater left: 8.00 m

**Single load acting on the top of wall:**

| BS | x[m] | z [m] | Angle of load[ | P[kN/m] | Frictio |
|---|---|---|---|---|---|
| BS-P(1g) | -0.80 | 0.00 | 270.00 | 100.00 | Yes |

BS-P(1g) Total load on top of the wall: 100 kN/m

**Soil layers:**

| Name | phi[°] | delta | Cohesion | gamma | gamma' | Es |
|---|---|---|---|---|---|---|
| Erde1 | 30.00 | 20.00 | 0.00 | 20.00 | 10.00 | 10000 |
| Kies | 30.00 | 0.00 | 0.00 | 20.00 | 10.00 | 0 |
| Erde2 | 25.00 | 13.00 | 0.00 | 18.00 | 11.00 | 10000 |

**Loads:**

Units ... Strip load [kN/m2], Line load [kN/m]

| Load type | BS | x1 [m] | z1 [m] | b [m] | q1 | q2 | Redistri. | ph [kN/m] | S' [kN/m] |
|---|---|---|---|---|---|---|---|---|---|
| Strip | BS-P(1g) | 0.00 | 0.00 | --- | 15.00 | 15.00 | No | - | - |
| Block | BS-P(1g) | 0.00 | 0.00 | 2.00 | 60.00 | 60.00 | Constant | - | - |

# Results:

## Earth pressure:

### Earth pressure options:

```
 Load calculation iterative:          No
 Consider cohesion          acc. to classical approach
     (kach=2*(sqrt(kah))*cos(delta)
 Calculation of                      active earth pressure
 Considering of earth resistance?    with 50%
```

### Earth pressure coefficient:

| No. | Name | φ[°] | δ[°] | α[°] | β[°] |
|---|---|---|---|---|---|
| 1 | Erde1 | 30.00 | 20.00 | 0.00 | 0.00 |
| 2 | Erde2 | 25.00 | 13.00 | -8.13 | 0.00 |
| 3 | Erde2 | 25.00 | 13.00 | 0.00 | 0.00 |
| 4 | Kies | 30.00 | 0.00 | 0.00 | 0.00 |

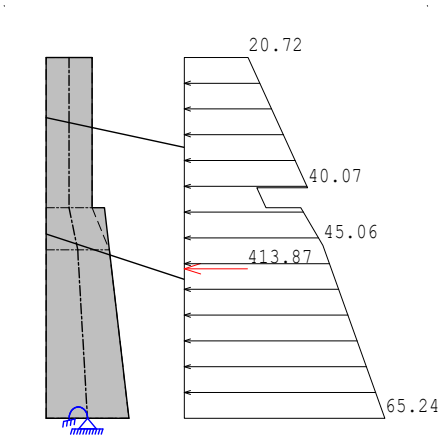
| No. | Kah | Kach | K0h | Kph | Kpch |
|---|---|---|---|---|---|
| 1 | 0.279 | --- | --- | --- | --- |
| 2 | 0.399 | --- | --- | --- | --- |
| 3 | 0.357 | --- | --- | --- | --- |
| 4 | --- | --- | --- | 3.000 | --- |

### Earth pressure redistribution:

```
 Distribution:                              rectangular
 Consider loads:          from g and p
```

### Characteristical horizontal rate of the earth pressure (not redistributed):

**BS-P(1g):**



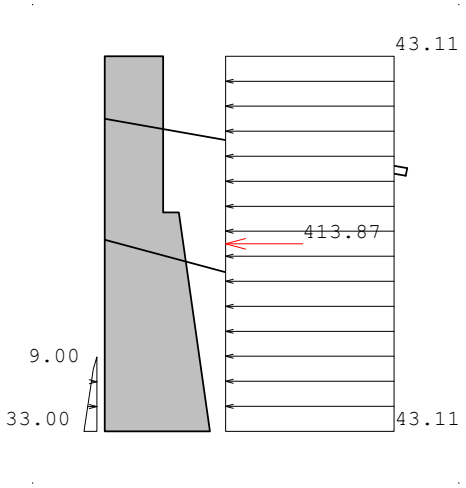

| z-Koo[m] | eh[kN/m2] |
|---|---|
| 0.000 | 0.000 |
| 0.000 | 20.718 |
| 3.464 | 40.074 |
| 3.464 | 23.547 |
| 4.000 | 26.541 |
| 4.000 | 37.883 |
| 5.000 | 45.060 |
| 9.600 | 65.238 |

| | |
|---|---|
| 9.600 | 0.000 |

**Characteristical horizontal rate of the earth pressure (redistributed):**

| z-Koo[m] | eh[kN/m2] |
|---|---|
| 7.700 | 0.000 |
| 8.000 | 9.000 |
| 9.600 | 33.000 |
| 9.600 | 0.000 |

**BS-P(1g):**




| z-Koo[m] | eh[kN/m2] |
|---|---|

| | |
|---|---|
| 0.000 | 0.000 |
| 0.000 | 43.112 |
| 9.600 | 43.112 |
| 9.600 | 0.000 |

**Loading of beam axis:**

Line loads: Excavation state 'B'

| Beam no. | z-Koo[m] | Ph[kN/m²] | Pv[kN/m²] | M[kNm/m] |
|---|---|---|---|---|
| 0 | 0.000 | 43.112 | 15.691 | 0.000 |
| | 1.732 | 43.112 | 15.691 | 0.000 |
| 1 | 1.732 | 43.112 | 15.691 | 0.000 |
| | 4.000 | 43.112 | 15.691 | 0.000 |
| 2 | 4.000 | 43.112 | 16.661 | 0.000 |
| | 4.966 | 43.112 | 16.661 | 0.000 |
| 3 | 4.966 | 43.112 | 16.661 | 0.000 |
| | 5.000 | 43.112 | 16.661 | 0.000 |
| 4 | 5.000 | 43.112 | 16.661 | 0.000 |
| | 5.120 | 44.300 | 16.831 | 0.000 |
| 5 | 5.120 | 44.300 | 16.831 | 0.000 |
| | 7.700 | 69.840 | 20.480 | 0.000 |
| 6 | 7.700 | 69.840 | 20.480 | 0.000 |
| | 8.000 | 63.810 | 20.904 | 0.000 |
| 7 | 8.000 | 63.810 | 20.904 | 0.000 |
| | 9.600 | 39.649 | 23.167 | 0.000 |

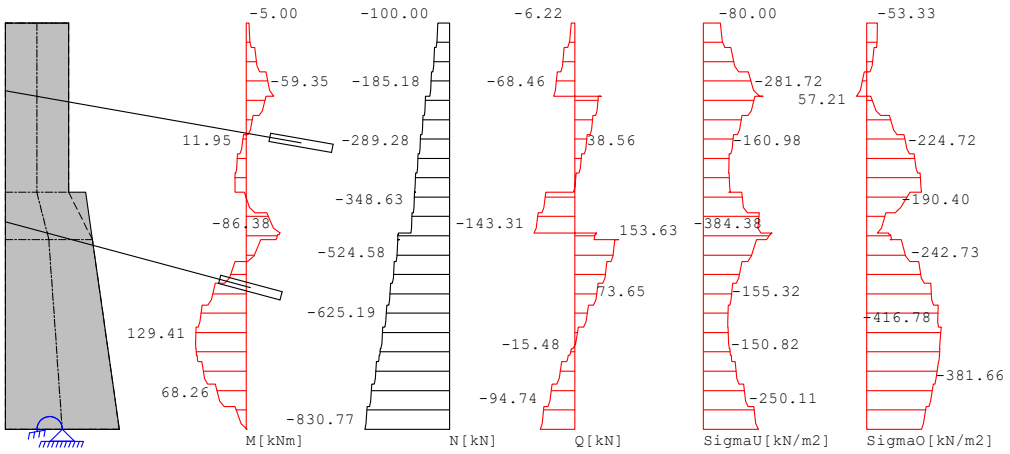
Point loads: Excavation state 'B'

| Beam no. | z-Koo[m] | Ph[kN/m] | Pv[kN/m] | M[kNm/m] |
|---|---|---|---|---|
| | 9.600 | 0.000 | -83.700 | -0.000 |

**Characteristic stress resultants:**

All sections refer to 1m wall width.

**BS-P(1g):**




| Beam no. | z-Koo[m] | M[kNm] | N[kN] | Q[kN] | Px[kN/m2] |
|---|---|---|---|---|---|
| 1 | 0.000 | -5.000 | -100.000 | 0.000 | 0.000 |
| 1 | 0.577 | -12.187 | -130.973 | -24.893 | 0.000 |
| 1 | 1.010 | -27.010 | -154.204 | -43.563 | 0.000 |
| 1 | 1.155 | -49.918 | -177.434 | -62.233 | 0.000 |

| | | | | | |
|---|---|---|---|---|---|
| 1 | 1.732 | -69.682 | -192.920 | -74.680 | 0.000 |
| 2 | 1.732 | -69.682 | -222.370 | 92.336 | 0.000 |
| 2 | 2.186 | -24.262 | -252.781 | 67.894 | 0.000 |
| 2 | 2.639 | 7.302 | -283.193 | 43.453 | 0.000 |
| 2 | 3.433 | 25.008 | -313.604 | 19.011 | 0.000 |
| 2 | 4.000 | 28.858 | -344.016 | -5.431 | 0.000 |
| 3 | 4.000 | 28.858 | -332.427 | -88.705 | 0.000 |
| 3 | 4.362 | -7.999 | -348.631 | -108.848 | 0.000 |
| 3 | 4.483 | -36.780 | -360.328 | -122.500 | 0.000 |
| 3 | 4.966 | -86.377 | -379.213 | -143.313 | 0.000 |
| 4 | 4.966 | -86.377 | -500.786 | 75.683 | 0.000 |
| 4 | 4.966 | -85.045 | -501.722 | 74.686 | 0.000 |
| 4 | 5.000 | -83.732 | -502.661 | 73.688 | 0.000 |
| 5 | 5.000 | -83.732 | -502.661 | 73.688 | 0.000 |
| 5 | 5.000 | -79.283 | -505.969 | 70.176 | 0.000 |
| 5 | 5.120 | -75.053 | -509.318 | 66.617 | 0.000 |
| 6 | 5.120 | -75.053 | -490.145 | 153.625 | 0.000 |
| 6 | 5.636 | 13.590 | -533.365 | 119.827 | 0.000 |
| 6 | 6.152 | 79.001 | -578.379 | 81.773 | 0.000 |
| 6 | 7.055 | 118.428 | -625.185 | 39.461 | 0.000 |
| 6 | 7.700 | 129.118 | -673.785 | -7.108 | 0.000 |
| 7 | 7.700 | 129.118 | -673.785 | -7.108 | 0.000 |
| 7 | 7.813 | 127.842 | -682.459 | -15.477 | 0.000 |
| 7 | 7.850 | 126.473 | -688.287 | -20.918 | 0.000 |
| 7 | 8.000 | 123.663 | -697.097 | -28.872 | 0.000 |
| 8 | 8.000 | 123.663 | -697.097 | -28.872 | 0.000 |
| 8 | 8.533 | 98.675 | -739.923 | -63.896 | 0.000 |
| 8 | 8.933 | 68.256 | -773.179 | -87.420 | 0.000 |
| 8 | 9.067 | 28.876 | -807.410 | -108.591 | 0.000 |
| 8 | 9.600 | -1.891 | -830.772 | -121.398 | 0.000 |

**Characteristic cross-section stresses:**

**BS-P(1g):**

| Beam no. | z-Koo[m] | SigmaU[kN/m2] | SigmaO[kN/m2] |
|---|---|---|---|
| 1 | 0.000 | -80.000 | -53.333 |
| 1 | 0.577 | -119.814 | -54.817 |
| 1 | 1.010 | -174.829 | -30.776 |
| 1 | 1.155 | -251.404 | 14.826 |
| 1 | 1.732 | -314.433 | 57.206 |
| 2 | 1.732 | -334.066 | 37.573 |
| 2 | 2.186 | -233.219 | -103.823 |
| 2 | 2.639 | -169.324 | -208.266 |
| 2 | 3.433 | -142.382 | -275.758 |
| 2 | 4.000 | -152.390 | -306.298 |
| 3 | 4.000 | -144.665 | -298.572 |
| 3 | 4.362 | -224.372 | -190.404 |
| 3 | 4.483 | -279.688 | -134.146 |
| 3 | 4.966 | -323.068 | -59.430 |
| 4 | 4.966 | -384.381 | -120.743 |
| 4 | 4.966 | -382.822 | -123.246 |
| 4 | 5.000 | -376.929 | -125.733 |
| 5 | 5.000 | -376.929 | -125.733 |
| 5 | 5.000 | -371.909 | -134.060 |
| 5 | 5.120 | -353.358 | -141.125 |
| 6 | 5.120 | -344.051 | -131.818 |
| 6 | 5.636 | -232.060 | -267.880 |
| 6 | 6.152 | -164.738 | -359.292 |
| 6 | 7.055 | -137.415 | -397.748 |
| 6 | 7.700 | -146.089 | -408.793 |
| 7 | 7.700 | -146.089 | -408.793 |
| 7 | 7.813 | -150.816 | -407.515 |
| 7 | 7.850 | -154.513 | -407.354 |
| 7 | 8.000 | -160.585 | -403.540 |
| 8 | 8.000 | -160.585 | -403.540 |
| 8 | 8.533 | -199.217 | -381.657 |
| 8 | 8.933 | -236.472 | -357.194 |
| 8 | 9.067 | -282.558 | -332.891 |
| 8 | 9.600 | -309.250 | -306.137 |

**Deformation due to characteristic load:**

**BS-P(1g):**

| x-Coo[m] | z-Koo[m] | dx [mm] | dz [mm] |
|---|---|---|---|
| -0.75 | 0.00 | -0.02487 | 0.07786 |
| -0.75 | 0.58 | -0.02006 | 0.07622 |
| -0.75 | 1.15 | -0.01583 | 0.07414 |
| -0.75 | 1.73 | -0.01313 | 0.07162 |
| -0.75 | 1.73 | -0.01313 | 0.07162 |
| -0.75 | 2.19 | -0.01274 | 0.06900 |
| -0.75 | 2.64 | -0.01325 | 0.06612 |
| -0.75 | 3.09 | -0.01387 | 0.06296 |
| -0.75 | 3.55 | -0.01408 | 0.05953 |
| -0.75 | 4.00 | -0.01358 | 0.05582 |
| -0.75 | 4.00 | -0.01358 | 0.05582 |
| -0.63 | 4.48 | -0.01340 | 0.05164 |
| -0.51 | 4.97 | -0.01357 | 0.04784 |
| -0.51 | 4.97 | -0.01357 | 0.04784 |
| -0.50 | 5.00 | -0.01364 | 0.04751 |
| -0.50 | 5.00 | -0.01364 | 0.04751 |
| -0.47 | 5.12 | -0.01394 | 0.04637 |
| -0.47 | 5.12 | -0.01394 | 0.04637 |
| -0.43 | 5.64 | -0.01478 | 0.04179 |
| -0.40 | 6.15 | -0.01569 | 0.03706 |
| -0.36 | 6.67 | -0.01601 | 0.03214 |

| | | | |
|---|---|---|---|
| -0.32 | 7.18 | -0.01538 | 0.02700 |
| -0.29 | 7.70 | -0.01365 | 0.02163 |
| -0.29 | 7.70 | -0.01365 | 0.02163 |
| -0.27 | 7.85 | -0.01295 | 0.02003 |
| -0.26 | 8.00 | -0.01216 | 0.01840 |
| -0.26 | 8.00 | -0.01216 | 0.01840 |
| -0.23 | 8.53 | -0.00873 | 0.01248 |
| -0.19 | 9.07 | -0.00455 | 0.00634 |
| -0.15 | 9.60 | 0.00000 | 0.00000 |

**Support reactions, characteristic:**

**Load case 1(g):**

Support reaction top: Support free movable
Support reaction bottom: Fx: -61.90 kN/m Fz: 753.61 kN/m M: -1.89 kNm/m

**Characteristic anchor and supporting forces:**

| Anchor 1 | z-Koo[m] | Force[kN/m] |
|---|---|---|
| BS-P(1g) | 1.60 | 169.59 |

| Anchor 3 | z-Koo[m] | Force[kN/m] |
|---|---|---|
| BS-P(1g) | 4.70 | 250.48 |

**ULS and SLS design:**

```
 Standard:                          DIN EN 1992-1-1
 Concrete wall:                    C12/15
 Reinforcement:                    B500S
 Concrete weight:                  25.00 kN/m3
 Reinforcement center distance hb, wall:        5.00 cm
 Reinforcement center distance ht, wall:        5.00 cm
```

**Design options:**

```
 Consider earth resistance:                                    Yes
 Consider load on excavation side:                             No
 Consider earth pressure due to soil weight:                 Yes
 Consider loadings right:                                                Yes
 Consider user-defined earth pressures:                          No
 Consider hydrostatic pressure due to groundwate on right sider:          Yes
 Consider hydrostatic pressure due to groundwater:             Yes
 Consider user-defined loading due to water on right side:      No
 Consider wall weight:                                  Yes
 Consider vertical parts of the earth pressures:                  Yes
 Consider moment parts of the earth pressure:                   No

 Requirements class:                    Class E
 Structural member:                     Slab
 Structure type:
Building construction/Building construction
 Exposure classes:
   XC4: Alternating wet and dry
   XD2: Wet, rarely dry
   XS1: Saline air but no contact to sea water

 ULS design:
   Minimum longitudinal reinforcement   No
   Min. shear force reinforcement       No
   Design of the wall as compression memNo

 SLS design:
   Final crack - direct crack width computation

   Minimum reinforcement: Individual craYes
   Calculated crack width               0.30 mm
   Limiting diameter top                16.00 mm
   Limiting diameter bottom             16.00 mm
```

**Material coefficients:**

| | permanent/transient | Accidental | Coefficient acc. for |
|---|---|---|---|
| Concrete | 1.50 | 1.20 | 0.85 |
| Reinforcemen | 1.15 | 1.00 | |

**Design sections:**

relating to 1m wall width

| No. | xm[m] | zm[m] | d[cm] |
|---|---|---|---|

**Design sections: BS-P(1)**

```
 γG      ... Partial safety factor -  GZ1B permanent actions
 γQ      ... Partial safety factor -  GZ1B variable actions
 Mkg     ... Characteristical permanent moment
 Mkq     ... Characteristical variable moment
 Md      ... Design moment Md
 Nkg     ... Characteristical permanent normal force
 Nkq     ... Characteristical variable normal force
```

```
 Nd       ... Design normal force
 Qkg      ... Characteristical permanent shear force
 Qkq      ... Characteristical variable shear force
 Qd       ... Design shear force
 Md = Mkg*γG + Mkq*γQ
 Nd = Nkg*γG + Nkq*γQ
 Qd = Qkg*γG + Qkq*γQ

 psi1         ... Combination coefficient for frequent loading
 psi2         ... Combination coefficient for quasi, permanent loading
 M,Q,N_rare   ... characteristic stress resultants, rare loading
 M,Q,N_freq   ... characteristic stress resultants, frequent loading
 M,Q,N_quasi  ... characteristic stress resultants, quasi, permanent loading

  M_rare   = Mkg+ Mkq
  M_freq   = Mkg+ Mkq*psi1
  M_quasi  = Mkg+ Mkq*psi2


 αc       ... Solidity coefficient = 0.81
 fck      ... Characteristical cylinder strength of the concrete
 γc       ... Partial safety factor of the plain concrete γc=γ
c*1.2= 1.5*1.2=1.80
 αD       ... Reduction factor due to load transfer=0.85
 NRd      ... Structure resistance normal force
 MRd      ... Structure resistance bending moment
```

**Stress resultants due to ULS**

| No. | γG | γQ | Mkg | Mkq | Md | Nkg | Nkq | Nd |
|---|---|---|---|---|---|---|---|---|

| No. | Qkg | Qkq | Qd |
|---|---|---|---|

**Stress resultants SLS**

| No. | psi1 | psi2 | γG | γQ | M,rare | M,freq | M,quasi |
|---|---|---|---|---|---|---|---|

| No. | N,rare | N,freq | N,quasi | Q,rare | Q,freq | Q,quasi |
|---|---|---|---|---|---|---|

**Necessary longitudinal reinforcement due to ULS and SLS:**

aso [cm2] ... Required longitudinal reinforcement top
asu [cm2] ... Required longitudinal reinforcement bottom
epsz[o/oo] ... Steel strain
epsd[o/oo] ... Concrete compressive strain
zi[m] ... Inner lever arm

| No. | aso | asu | epsz | epsd | zi |
|---|---|---|---|---|---|

**Necessary shear reinforcement due to ULS and SLS:**

ass[cm2/m] ... Required shear reinforcement, under 90°
VRdct[kN] ... Shear force capacity of the bending reinforcement
VRdmax[kN] ... Shear force capacity of the compressive strut
vsd [kN] ... Decisive shear force
VRd,s[kN] ... Shear force capacity of the shear reinforcement component
rho[%] ... Percentage of reinforcement longitudinal
theta[°] ... Compression strut inclination asccording to DAfStb/H.425

| No. | ass | vsd | VRdct | VRdmax | VRd,s | rho | theta |
|---|---|---|---|---|---|---|---|

**Design of the plain concrete in STR/GEO-2:**

**BS-P(1g):**

**Soil mechanic analysis of the overall stability:**

relating to 1m wall width

**Bottom pressure in GEO-2:**

Resultant force of foundation joint :

| BS | Rk | Rvk,g | Rhk,g | Rvk,q | Rhk,q | gamma_g | gamma_q | Rvd | Rhd | Rd |
|---|---|---|---|---|---|---|---|---|---|---|
| BS-P(1g) | 756.15 | 753.61 | 61.90 | 0.00 | 0.00 | 1.35 | 1.50 | 1017.37 | 83.56 | 1020.80 |

Embedment depth: 1.90 m
User-defined admissible stress: Yes
reduced width b' b'= 2* (b/2- e) e...Eccentricity

| BS | b'[m] | Rvd[kN] | Rvk,g | Rvk,q | exisσ,d | admσ,d | |
|---|---|---|---|---|---|---|---|
| BS-P(1g) | 2.69 | 1017.37 | 753.61 | 0.00 | 377.51 | 300.00 | not fulfilled |

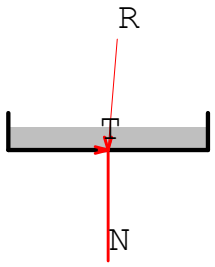
**Lateral buckling analysis for EQU, permanent loads**

```
Length of the the foundation bottom edge b:    2.700 m
Admissible eccentricity for dead load b/6:     0.450 m

Rk [kN]    ... Resulting characteristical loading
Asohl [%] ... Overpressed floor level
```

| BS | Rk[kN] | exis.e[m] | adm.e[m] | Abase[%] | Verifi. complied |
|---|---|---|---|---|---|
| BS-P(1g) | 756.15 | 0.00 | 0.45 | 100.00 | Yes |

**Slip verification by GEO-2:**




Sliding safety:

Resultant force of foundation joint (without contribution of the passive earth pressure):

| BS | Rk | Rvk,g | Rhk,g | Rvk,q | Rhk,q |
|---|---|---|---|---|---|
| BS-P(1g) | 760.75 | 755.30 | 90.88 | 0.00 | 0.00 |

```
floor level friction coefficient:                    seated equal to phi
Consider earth resistance:              with 50%
weighted phi of the surrounding soil layer:  25.00 °
Inclination of floor level:                              0.00 °

Ep[kN]   ... Earth resistance without reduction
Epk[kN]  ... Characteristical, mobilized value of the earth resistance
γEpk     ... Partial safety factor - earth resistance
Epd[kN]  ... Design value of earth resistance

Rtd[kN]  ... Design value of the sliding resistance
Rtk[kN]  ... Characteristical sliding resistance
γGl      ... Partial safety factor - limit state GZ1B

Nk[kN]   ... Vertical acting component of the characteristical stress
δSk[°]   ... Chara. value of the angle of skin friction in the floor level

Td[kN]   ... Design value of the stress parallel to the floor level
TGk[kN]  ... Due to permanent loads
TQk[kN]  ... Due to live loads
γG       ... Partial safety factor - permanent actions GZ1B
γE0g     ... Partial safety factor - earth pressure at rest GZ1B
γQ       ... Partial safety factor - unfavorable variable actions GZ1B
```

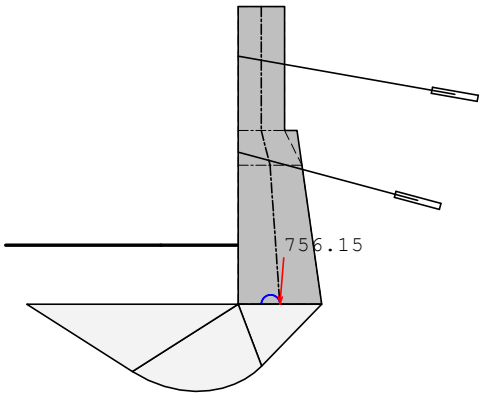
**BS-P(1g):**

```
Epk = Ep*0.50= 69.90*0.50 = 34.95 kN
Epk>Tk = 34.95>90.88  ... Epk=Tk= 90.88
Epd = Epk/γEp = 34.95/1.40 = 24.96 kN
Rtk = Nk*tanδSk = 755.30*tan(25.00°) = 352.20 kN
Rtd = Rtk/γGl = 352.20/1.10 = 320.18 kN
Td = TGk*γG + TQk*γQ = 90.88*1.35 + 0.00*1.50 = 122.69 kN
Td <= Rtd + Epd      122.69<=320.18+24.96
... Analysis fulfilled BS-P(1g)
```

**Base failure analysis by GEO-2:**

Resultant force of foundation joint (without contribution of the passive earth pressure):

| BS | Rk | Rvk,g | Rhk,g | Rvk,q | Rhk,q | gamma_g | gamma_q | Rvd | Rhd | Rd |
|---|---|---|---|---|---|---|---|---|---|---|
| BS-P(1g) | 760.75 | 755.30 | 90.88 | 0.00 | 0.00 | 1.35 | 1.50 | 1019.66 | 122.69 | 1027.01 |




Fracture body, LC 1(g)

**Base failure resistance formula:**

Rnk =a'*b'* [γ2*b'*Nb + (γ1*d+q) *Nd + c*Nc] ... DIN 4017

A strip foundation is assumed.
b' = b-2eb
Nb = Nb0 * νb * ib * λb * ξb
Nd = Nd0 * νd * id * λd * ξd
Nc = Nc0 * νc * ic * λc * ξc

Ground slope at excavation side: 0.00 °
Inclination of floor level: 0.00 °

Nk ... Characteristical stress vertical to the foundation floor
Tk ... Characteristical stress parallel to the foundation floor
delta ... Load inclination tan(delta)= Tk/Nk
Rnk ... Characteristical base failure resistance
Rnd ... Design value of the base failure resistance = Rnk / Safety

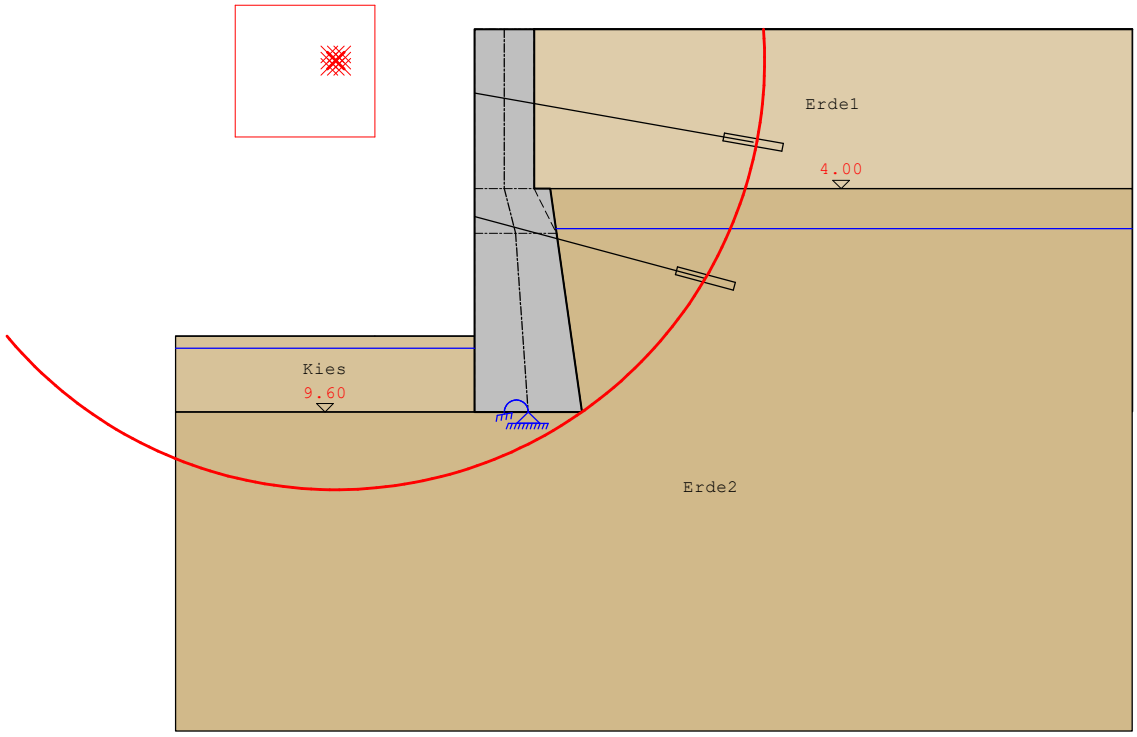
| BS | Form | Inclin. | Structural stre | Ground incli. | Base incli. | Design force |
|---|---|---|---|---|---|---|
| BS-P( | νc: 1.00 | ic: 0.75 | Nc0: 20.72 | λc: 1.00 | ξc: 1.00 | N: 1019.66 |
| | νd: 1.00 | id: 0.77 | Nd0: 10.66 | λd: 1.00 | ξd: 1.00 | T: 122.69 |
| | νb: 1.00 | ib: 0.68 | Nb0: 4.51 | λb: 1.00 | ξb: 1.00 | eb: 0.00 |

|delta|=6.86° <= φk=25.00°
Nd=NG,k*γG + NQ,k*γQ = 755.30*1.35 + 0.00*1.50= 1019.66 kN
Td=TG,k*γG + TQ,k*γQ = 90.88*1.35 + 0.00*1.50= 122.69 kN
Rnk=1.00*2.69* [11.00*2.69*3.07 +
(11.58*1.90+0.00) *8.25 +
0.00*15.55]= 734.09 kN

Rnd= Rnk / γGr= 734.09/1.40= 524.35 kN
Rnd < Nd ... Verification failed

Verification of the design situation BS-P(1g) not achieved

**Slip circle analysis by GEO-3:**




Slip circle with minimum safety

Number of examined circles: 253
Grid spacing of the center of circles: x:0.16 m z:0.15 m

**Relevant slip circle:**

| BS | x-Coo[m] | z-Koo[m] | Radius[m] | Rd | Ed | Rd/Ed | fulfill |
|---|---|---|---|---|---|---|---|
| BS-P(1g) | -4.98 | 0.79 | 10.76 | 661.25 | 849.28 | 0.78 | No |

**Settlement analysis in SLS**

Settlement in the left (A) and right point (B) at the bottom edge of the wall.
A gaping joint exists, if the resultant of the base pressure is within the core.

User-def. embedment depth: None calculated depth: 1.90 m
set limiting depth: None calculated depth: 5.40 m

| BS | Point A[cm] | Point B[cm] | Gaping joint: |
|---|---|---|---|
| BS-P(1g) | 5.72 | 5.28 | not existing |

## Overview of the analyses

**Overview safety verifications overall stability**

**Bottom pressure in GEO-2:**

| BS | b'[m] | Rvd[kN] | Rvk,g | Rvk,q | exisσ,d | admσ,d |
|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| BS-P(1g) | 2.69 | 1017.37 | 753.61 | 0.00 | 377.51 | 300.00 | not fulfilled |

**Lateral buckling analysis for EQU, permanent loads**

| BS | Rk[kN] | exis.e[m] | adm.e[m] | Abase[%] | Verifi. complied |
|---|---|---|---|---|---|
| BS-P(1g) | 756.15 | 0.00 | 0.45 | 100.00 | Yes |

**Slip verification by GEO-2:**

Td <= Rtd + Epd 122.69<=320.18+24.96 ... Analysis fulfilled BS-P(1g)

**Base failure analysis by GEO-2:**

BS-P(1g): Rnd < Nd = 524.35< 1019.66 ... Verification not ok

Verification of the design situation BS-P(1g) not achieved

**Slip circle analysis by GEO-3:**

Relevant slip circle:

| BS | x-Coo[m] | z-Koo[m] | Radius[m] | Rd | Ed | Rd/Ed | fulfill |
|---|---|---|---|---|---|---|---|
| BS-P(1g) | -4.98 | 0.79 | 10.76 | 661.25 | 849.28 | 0.78 | No |

**Necessary longitudinal reinforcement due to ULS and SLS: (LF BS-P(1))**

| No. | aso | asu | epsz | epsd | zi |
|---|---|---|---|---|---|

**Necessary shear reinforcement due to ULS and SLS: (LF BS-P(1))**

| No. | ass | vsd | VRdct | VRdmax | VRd,s | rho | theta |
|---|---|---|---|---|---|---|---|

# Anchor analysis in GEO-2:

```
Ahmög    ... Sustainable horizontal part of the anchor force
Ahmög,k  ... Characteristical horizontal part of the anchor force
Ahmög,d  ... Characteristical value / γEP
Ahvor,d  ... Sustainable horizontal part of the anchor force (design value)
Ahmög,k  ... Characteristical anchor force
min lm   ... User-defined minimum anchor length
erf lm   ... Iterative calculated minimum required anchor length
Ares     ... Characteristical resulting anchor force
Ah       ... Horizontal rate of Ares
Av       ... Vertical rate of Ares
```

Construction state 'A'

```
Using of minimum length of the previous construction state: yes
Toe level of the deep seated stability: z=9.60 m
```

Construction state 'B'

```
Using of minimum length of the previous construction state: yes
Toe level of the deep seated stability: z=9.60 m
```