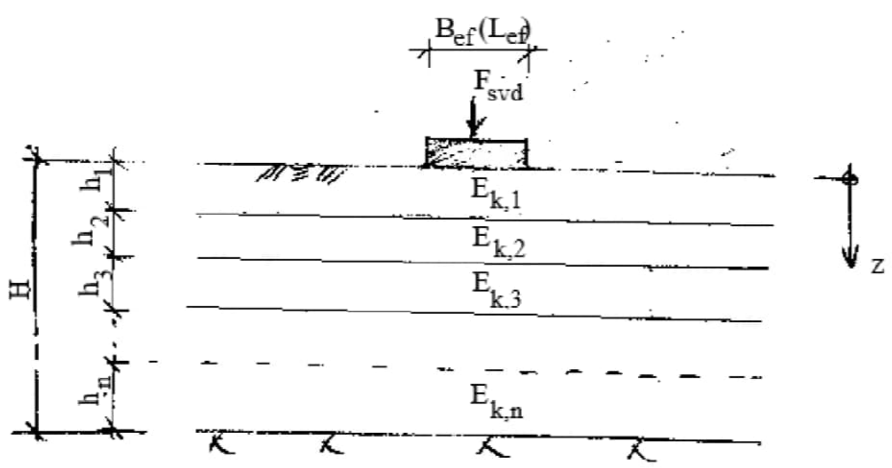
<u>Object:</u> Support 1 - SLS

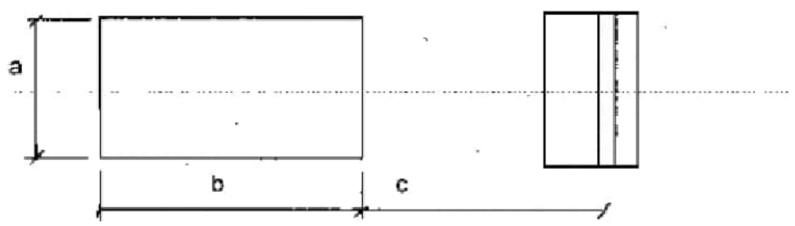
PRINCIPLE SKETCH

Calculation accordint to TRVINFRA-00227 attachment 4.

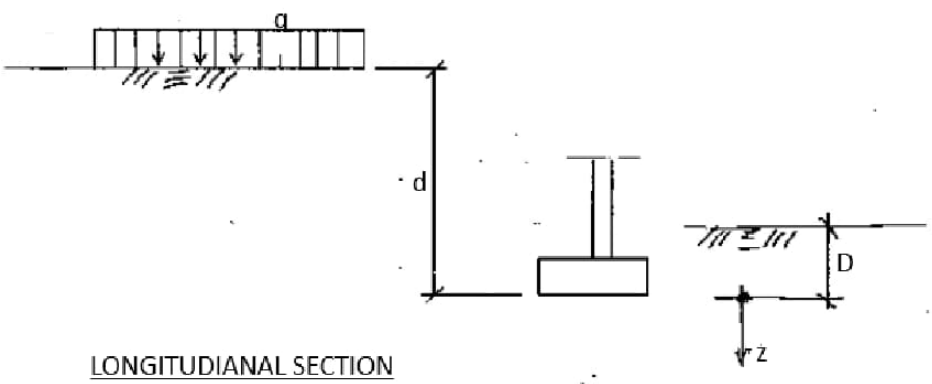
Defintion soil layers



Effect load from nearby bank



PLAN



LONGITUDIANAL SECTION

INPUT

Vertical design load

$F_{Svd} := 4711 \cdot kN$ $B_{ef} := 3.52 \cdot m$ $L_{ef} := 8.0 \cdot m$

Vertical pressure at foundation level
(Reduction considers long-time loading before production of support)

$\sigma_{vo} := 0 \cdot kPa$

Technical lifespan

$t := 120 \cdot years$

Existance of "silt"
Dominates "silt" ("ja" or "nej) : $silt :=$ “Nej”

Foundation depth

$D := 1.8 \cdot m$

Additional pressure due to load on connecting bank
Long-term load from connecting bank that acts after production of support. Normally no live load ist consider for SLS-Q noll.

$a := 8.0 \cdot m$ $b := 2 \cdot a = 16\ m$ $c := 1.1 \cdot m$ $d := 6.0 \cdot m$

$q := 0 \cdot kPa$

Defintion soil layers
Number of layers (minimum of 2 pcs): $n := 3 \cdot pcs$

Earth-factor λ is defined by soil composition:
λ = 0 for coarse frictional material
λ = 0.5 for "silt"
λ = 1.0 for cohesion material

Pressure exponent β :
β = 1.0 for overconsolidated cohesion material
β = 0.5 for coarse "silt", sand and gravel

Layer	E_d	E_k	h	γ	λ	β
1	50	35	2,00	18	0	0,5
2	50	35	2,00	18	0	0,5
3	50	35	2,00	18	0	0,5
-	MPa	MPa	m	kN/m^3	-	-

CALCULATIONS

Effect of "silt"

$\gamma_{Rd} := \textbf{if}\left(silt = \text{“Ja”}, 1.1, 1.0\right)$ $\quad\quad$ $\gamma_{Rd} = 1.0$

Total layer thickness

$H := \sum_{i=1}^{n} h_i$ $\quad\quad$ $H = 6.000\ m$

Levels of studied soil layers

$$z_s = \left| \begin{array}{l} z_1 = 0mm \\ \text{for } i \in 1..n \\ \quad \left| \begin{array}{l} z_{2 \cdot i} = z_{2 \cdot i-1} + h_i - 1mm \\ z_{2 \cdot i+1} = z_{2 \cdot i} + 1mm \end{array} \right. \end{array} \right.$$

z_s [m]	0	2,000	2,001	4,000	4,001	6,000	6,001

Function - settlement modulus

Characteristic values:

$$E_{sk} = \left| \begin{array}{l} E_{sk_1} = E_{k_1} \\ \text{for } i \in 1..n-1 \\ \quad \left| \begin{array}{l} E_{sk_{2 \cdot i}} = E_{k_i} \\ E_{sk_{2 \cdot i+1}} = E_{k_{i+1}} \end{array} \right. \\ E_{sk_{2 \cdot n}} = E_{k_n} \\ E_{sk_{2 \cdot n+1}} = 1000MPa \end{array} \right.$$

E_{sk} [MPa]	35	35	35	35	35	35	1000

$E_{sk}(z) := \text{linterp}\left(z_s, E_{sk}, z\right)$

Design settlement values :

$$E_{sd} = \left| \begin{array}{l} E_{sd_1} = E_{d_1} \\ \text{for } i \in 1..n-1 \\ \quad \left| \begin{array}{l} E_{sd_{2 \cdot i}} = E_{d_i} \\ E_{sd_{2 \cdot i+1}} = E_{d_{i+1}} \end{array} \right. \\ E_{sd_{2 \cdot n}} = E_{d_n} \\ E_{sd_{2 \cdot n+1}} = 1000\,MPa \end{array} \right.$$

E_{sd} [MPa]	50	50	50	50	50	50	1000

$$E_{sd}(z) := \text{linterp}(z_s, E_{sd}, z)$$

Function - earth factor

$$\lambda_s = \left| \begin{array}{l} \lambda_{s_1} = \lambda 1 \\ \text{for } i \in 1..n-1 \\ \quad \left| \begin{array}{l} \lambda_{s_{2 \cdot i}} = \lambda i \\ \lambda_{s_{2 \cdot i+1}} = \lambda i+1 \end{array} \right. \\ \lambda_{s_{2 \cdot n}} = \lambda n \\ \lambda_{s_{2 \cdot n+1}} = 0 \end{array} \right.$$

λ_s [-]	0	0	0	0	0	0	0

$$\lambda(z) = \text{linterp}(z_s, \lambda_s, z)$$

Function - density

$$\gamma_s = \left| \begin{array}{l} \gamma_{s_1} = \gamma 1 \\ \text{for } i \in 1..n-1 \\ \quad \left| \begin{array}{l} \gamma_{s_{2 \cdot i}} = \gamma i \\ \gamma_{s_{2 \cdot i+1}} = \gamma i+1 \end{array} \right. \\ \gamma_{s_{2 \cdot n}} = \gamma n \\ \gamma_{s_{2 \cdot n+1}} = 0 \end{array} \right.$$

γ_s [kN/m^3]	18	18	18	18	18	18	0

$$\gamma(z) = \text{linterp}(z_s, \gamma_s, z)$$

Function - pressure exponent

$$\beta_s = \left| \begin{array}{l} \beta_{s_1} = \beta 1 \\ \text{for } i \in 1 .. n-1 \\ \quad \left| \begin{array}{l} \beta_{s_{2 \cdot i}} = \beta i \\ \beta_{s_{2 \cdot i+1}} = \beta_{i+1} \end{array} \right. \\ \beta_{s_{2 \cdot n}} = \beta n \\ \beta_{s_{2 \cdot n+1}} = 0 \end{array} \right.$$

$$\beta(z) = \text{linterp}(z_s, \beta_s, z)$$

Effective loading

$$q_{netto} := \frac{F_{Svd}}{B_{ef} \cdot L_{ef}} - \sigma_{vo} \qquad q_{netto} = 167\ kPa$$

Additional pressure due to load on connecting bank

$$m = \frac{a}{2(z+d)}$$

$$n_1 = \frac{b+c}{d+z}$$

$$n_2 = \frac{c}{d+z}$$

$$I_1 = \frac{1}{2 \cdot \pi} \cdot \left[\frac{m \cdot n_1 \cdot \left(2 + m^2 + n_1^2\right)}{\left(1+m^2\right) \cdot \left(1+n_1^2\right) \cdot \sqrt{1+m^2+n_1^2}} + \text{atan}\left(\frac{m \cdot n_1}{\sqrt{1+m^2+n_1^2}} \right) \right]$$

$$I_2 = \frac{1}{2 \cdot \pi} \cdot \left[\frac{m \cdot n_2 \cdot \left(2 + m^2 + n_2^2\right)}{\left(1+m^2\right) \cdot \left(1+n_2^2\right) \cdot \sqrt{1+m^2+n_2^2}} + \text{atan}\left(\frac{m \cdot n_2}{\sqrt{1+m^2+n_2^2}} \right) \right]$$

$$\sigma'_{tillskott} = 2 \cdot q \cdot \left(I_1 - I_2\right)$$

Time factor

$$\chi_{tid} := 1 + 0.2 \cdot \log(10 \cdot t) \qquad \chi_{tid} = 1.62$$

Settlement method 1

$$\Delta\sigma_v = q_{netto} \cdot \frac{B_{ef} \cdot L_{ef}}{(B_{ef}+z)\cdot(L_{ef}+z)} + \sigma'_{tillskott}$$

$\eta := 0.70$

Charateristic settlement:

$$s_{k.1} := \eta \cdot \chi_{tid} \cdot \int_{0 \cdot m}^{H} \frac{\Delta\sigma_v(z)}{E_{kar}(z)}\, dz \qquad s_{k.1} = 14.8\ mm$$

Design settlement:

$$s_{d.1} := \eta \cdot \chi_{tid} \cdot \int_{0 \cdot m}^{H} \frac{\Delta\sigma_v(z)}{E_{dim}(z)}\, dz \qquad s_{d.1} = 10.4\ mm$$

Settlement method 2

$$g = 1 + 21.5 \cdot \left(\frac{B_{ef}}{L_{ef}} + 2.5 \right)^{-2.15}$$ $g = 3.12$

$$\sigma_{v.mo} = \sigma_{vo} + \gamma(z) \cdot z$$

$$\Delta\sigma_v = \begin{cases} \sigma'_{tillskott} \text{ if } \left(1 - \frac{1}{g} \cdot \frac{z}{B_{ef}}\right) \le 0 \\ q_{netto} \left[1 + (3 - 2 \cdot \lambda(z)) \cdot \frac{1}{g} \cdot \frac{z}{B_{ef}}\right] \cdot \left(1 - \frac{1}{g} \cdot \frac{z}{B_{ef}}\right)^3 + \sigma'_{tillskott} \text{ if } \left(1 - \frac{1}{g} \cdot \frac{z}{B_{ef}}\right) > 0 \end{cases}$$

$P_a := 100 \cdot kPa$

$\eta := 0.65$

Charateristic settlement:

$$\varepsilon(z) = \frac{P_a}{E_{sk} \cdot \beta(z)} \cdot \left[\left(\frac{\sigma_{v.mo} + \Delta\sigma_v}{P_a} \right)^{\beta(z)} - \left(\frac{\sigma_{v.mo}}{P_a} \right)^{\beta(z)} \right]$$

$$s_{k.2} := \eta \cdot \chi_{tid} \cdot \int_{0 \cdot m}^{H} \varepsilon(z)\, dz$$ $s_{k.2} = 21.6\ mm$

Design settlement:

$$\varepsilon(z) = \frac{P_a}{E_{sd} \cdot \beta(z)} \cdot \left[\left(\frac{\sigma_{v.mo} + \Delta\sigma_v}{P_a} \right)^{\beta(z)} - \left(\frac{\sigma_{v.mo}}{P_a} \right)^{\beta(z)} \right]$$

$$s_{d.2} := \eta \cdot \chi_{tid} \cdot \int_{0 \cdot m}^{H} \varepsilon(z)\, dz$$ $s_{d.2} = 15.1\ mm$

Settlement method 3

$$r_o := \sqrt{\frac{L_{ef} \cdot B_{ef}}{\pi}} \qquad r_o = 2.99\ m$$

$$\Delta S = \left| \begin{array}{l} \text{for } i \in 1..n \\ \quad \left| \begin{array}{l} n_{del} = \text{trunc}\left(\frac{h_i}{0.1m}\right) \\ \Delta h = \frac{h_i}{n_{del}} \\ \Delta S_i = 0 \\ \text{for } j \in 1..n_{del} \\ \quad \Delta S_i = \Delta S_i + 3.87 \cdot \left[\frac{z_{s_{2 \cdot i-1}} + \Delta h \cdot (j-1)}{r_o} + 1.82\right]^{-1.7} - 3.87 \cdot \left(\frac{z_{s_{2 \cdot i-1}} + \Delta h \cdot j}{r_o} + 1.82\right)^{-1.7} \end{array} \right. \end{array} \right.$$

ΔS [-]	0,58	0,27	0,15	0,50	0,50	0,50	0

$$r_1 := 0.5 \cdot m$$

$$c := \frac{4 \cdot r_1 \cdot r_o}{(r_1 + r_o)^2} \qquad c = 0.49$$

Verification of conditon r_e:

$$r_e := \left\| \begin{array}{l} \text{if } 1 \le \frac{L_{ef}}{B_{ef}} \le 20 \\ \quad \left\| 0.45 + 0.98 \cdot \left(\frac{L_{ef}}{B_{ef}} + 2.0\right)^{-0.42} \right. \\ \text{else} \\ \quad \left\| \text{“Avbryt”} \right. \end{array} \right. \qquad r_e = 0.983$$

$$d_e := 0.82 + 0.96 \cdot \left(\frac{D}{r_o} + 2.0\right)^{-2.4} \qquad d_e = 0.92$$

$$\eta := 1.10$$

Charateristic settlement:

$$s_o := q_{netto} \cdot r_o \cdot \sum_{i=1}^{n} \frac{\Delta S_i}{E_{k_i}}$$ $s_o = 14.3\ mm$

$$s_{k.3} := \eta \cdot \chi_{tid} \cdot \left(c \cdot r_e \cdot d_e \cdot s_o + \int_{0 \cdot m}^{H} \frac{\sigma'_{tillskott}(z)}{E_{kar}(z)} \, dz \right)$$ $s_{k.3} = 11.3\ mm$

Design settlement:

$$s_o := q_{netto} \cdot r_o \cdot \sum_{i=1}^{n} \frac{\Delta S_i}{E_{d_i}}$$ $s_o = 10.0\ mm$

$$s_{d.3} := \eta \cdot \chi_{tid} \cdot \left(c \cdot r_e \cdot d_e \cdot s_o + \int_{0 \cdot m}^{H} \frac{\sigma'_{tillskott}(z)}{E_{dim}(z)} \, dz \right)$$ $s_{d.3} = 7.9\ mm$

RESULTS

Characteristic settlement

$$s_k := \frac{s_{k.1} + s_{k.2} + s_{k.3}}{3}$$ $s_k = 15.9\ mm$

Design settlement

$$s_d := \frac{s_{d.1} + s_{d.2} + s_{d.3}}{3}$$ $s_d = 11.1\ mm$