SETTLEMENT LOADS ON TIE-RODS

Calculation conform CUR 166, 4th print, 2005

Version and date: 0.2 (28-2-2011)

Project:	POVM Bergambacht voorbeeldenboek: damwand OSPW
Projectcode:	103638
Subject:	Aanvullende kracht in anker door zakkende grond
Prepared by:	T. Naves

starting points

Item	Variable	Value	Unit
notation of reference level		NAP	
diameter tie rods	D_0	76,1	mm
axial stiffness of the tie rods	EA	955165	kN
spacing tie rods	a	1,4	m
angle of tie rods with the horizontal	β	40	degrees
length tie rods	L	25,4	m
tie rod force	F	457,8	kN / tie rod
surface level	$z_{surface}$	5,00	m + NAP
tie rod level	$z_{tie\ rod}$	3,00	m + NAP
groundwater level	$z_{groundwater}$	4,00	m + NAP

vertical settlement load on tie rod

is the tie rod in 'non-cohesive' or 'cohesive' soil?		cohesive	soil

2. calculation for cohesive soil

undrained shear strength soil	c_u	29	kPa
factor for shear load on tie rod due to settling soil (default value = 5)	α	9	-
vertical load on tie rod $q_z = c_u \cdot D \cdot (1 + \alpha)$	$q_{z;soil}$	16,9	kN/m
self-weight tie rod	$q_{z;self\text{-}weight}$	0,4	kN/m
vertical load on tie rod (including self-weight)	q_z	17,3	kN/m

increase of tie rod force due to settlement load - case 1: unlimited deformation

- iterative calculation based on the formula: $\alpha \cdot (1+\alpha)^2 = \left(\frac{q_0 L}{F}\right)^2 \cdot \frac{1}{4\pi^2 F\left(\frac{1}{EA}+\frac{1}{k'L}\right)}$

vertical load on tie rod	q_z	17,3	kN/m
maximum load based on sinusoidal waveform $q_0 = q_z \cdot 4/\pi$	q_0	22,0	kN/m
bending stiffness sheetpile	$EI_{sheetpile}$	2,36E+05	kNm^2/m
horizontal subgrade reaction modulus	k	4500	kN/m^3
wavelength $\lambda = \sqrt[4]{4EI/c}$	λ	3,81	m
relative stiffness of sheetpile wall	k'	23974	kN/m
ratio of tie rod force increase (calculate by iteration)	α	2,50	-
increase of tie rod force $F_z = \Delta F = \alpha \cdot F$	$\Delta F_{tie\ rod}$	**1143,7**	kN
maximum settlement of the tie rod $y_0 = L \cdot \left(\frac{q_0 \cdot L}{F}\right) \cdot \frac{1}{\pi^2} \cdot \frac{1}{1+\alpha}$	y_0	0,90	m

increase of tie rod force due to settlement load - case 2: limited deformation

- iterative calculation based on the formula: $\alpha_n^2(1+\alpha_n) = \alpha^2(1+\alpha) \cdot \frac{1}{n^3}$ -3,77787E+16

limited settlement of the tie rod	y_n	0,2	m
ratio of y_n and y_0 (maximum settlement) $n = \frac{y_0}{y_n}$	n	4,48	-
ratio of tie rod force increase (calculate by iteration)	α_n	0,41	-
part of the tie rod that is supported $\beta = 1 - \frac{\alpha}{\alpha_n \cdot n^2}$	β x L	17,8	m
increase of tie rod force $F_z = \Delta F = \alpha_n \cdot F$	$\Delta F_{tie\ rod}$	**189,5**	kN