

SETTLEMENT LOADS ON TIE-RODS

Calculation conform CUR 166, 4th print, 2005

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Project: POVM Bergambacht voorbeeldenboek: damwand BEEM
Projectcode: 103638
Subject: Aanvullende kracht in anker door zakkende grond
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Item	Variable	Value	Unit
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starting points

notation of reference level		NAP	
diameter tie rods	D_0	101,6	mm
axial stiffness of the tie rods	EA	1702537	kN
spacing tie rods	a	2,8	m
angle of tie rods with the horizontal	β	40	degrees
length tie rods	L	25,4	m
tie rod force	F	134,2	kN / tie rod
surface level	Z_{surface}	5,00	m + NAP
tie rod level	$Z_{\text{tie rod}}$	3,00	m + NAP
groundwater level	$Z_{\text{groundwater}}$	4,00	m + NAP

vertical settlement load on tie rod

is the tie rod in 'non-cohesive' or 'cohesive' soil?		cohesive	soil
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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 $q_z = c_u \cdot D \cdot (1 + \alpha)$	$q_{z;\text{soil}}$	22,6	kN/m
self-weight tie rod	$q_{z;\text{self-weight}}$	0,6	kN/m
vertical load on tie rod (including self-weight)	q_z	23,2	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	23,2	kN/m
maximum load based on sinusoidal waveform $q_0 = q_z \cdot 4/\pi$	q_0	29,5	kN/m
bending stiffness sheetpile	$EI_{\text{sheetpile}}$	1,38E+05	kNm ² /m
horizontal subgrade reaction modulus	k	4500	kN/m ³
wavelength $\lambda = \sqrt[4]{4EI/c}$	λ	3,33	m
relative stiffness of sheetpile wall	k'	41933	kN/m
ratio of tie rod force increase (calculate by iteration)	α	15,03	-
increase of tie rod force $F_z = \Delta F = \alpha \cdot F$	$\Delta F_{\text{tie rod}}$	2017,4	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	4,49	-
ratio of tie rod force increase (calculate by iteration)	α_n	3,11	-
part of the tie rod that is supported $\beta = 1 - \frac{\alpha}{\alpha_n \cdot n^2}$	$\beta \times L$	19,3	m
increase of tie rod force $F_z = \Delta F = \alpha_n \cdot F$	$\Delta F_{\text{tie rod}}$	417,8	kN