

VALIDATION REPORT

SPREADSHEET "GE Subgrade piles Ménard"

Version 1.0

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APPENDIX B RESULTS SPREAD SHEET CALCULATIONS



1 VERIFICATION SPREADSHEET

This spread sheet can be used to assess moduli for horizontal subgrade reaction for piles. Basis for determination of these parameter values is the method as proposed by Ménard (Publication: "General method to calculate a pile or diaphragm subject to horizontal loading in terms of pressuremeter tests results" - Ménard, Bourdon, Gambin - Soil 1968 VI (22/23)).

To determine the effects from a pile group on the soil reaction, recommendations according to Reese & Van Impe (Reese, L.X., Impe, W.F. van, Single Piles and Pile Groups Under Lateral Loading, Rotterdam A.A. Balkema, 2001) have been implemented.

1.1 Verification calculation (hand calculation)

A verification calculation was performed. Verification of the use of the right formula ($R < R_0$ or $R \geq R_0$) was given special attention.

Calculation 1

- pile 450 x 450 mm
- sand, normally consolidated; $\alpha = 0.33$
- $\beta = 0.85$
- $q_c = 12$ MPa

Calculation 2

- pile 600 x 600 mm
- sand, normally consolidated; $\alpha = 0.33$
- $\beta = 0.85$
- $q_c = 12$ MPa

The hand calculations are presented in Appendix A.

1.2 Spread sheet calculation

The calculations using the spread sheet are presented in Appendix B.



1.3 Summary results

Table 1: Calculation 1

Unit	Spreadsheet	Hand calculation	Difference
K_n [kN/m ³]	55540	55564	0.04%

Table 2: Calculation 2

Unit	Spreadsheet	Hand calculation	Difference
K_n [kN/m ³]	45540	45569	0.06%

The differences are marginal and acceptable.



Appendix 1: hand calculations

$$\text{paal } \square 450 \text{ mm} \rightarrow D_{eq} = \sqrt{945^2 / \pi} \times 2 = 0,50777 \text{ m.}$$
$$R = 0,25389 \text{ m}$$

Material : 2 and.

$$\alpha : 0,33$$

$$\beta : 0,85$$

$$q_c : 12 \text{ MPa}$$

$$E_m = \beta \times q_c = 0,85 \times 12 = 10,2 \text{ MPa} = 10,2 \cdot 10^3 \text{ kN/m}^2$$

K_h indien $R < R_0$ ($R_0 = 0,3$)

$$\frac{1}{K_h} = \frac{2 \times R}{E_m} \times \frac{4 \times (2,65)^\alpha + 3 \times \alpha}{18}$$
$$= \frac{2 \times 0,25389}{10,2 \cdot 10^3} \times \frac{4 \times (2,65)^{0,33} + 3 \times 0,33}{18}$$
$$= 4,97824 \cdot 10^{-5} \times 0,36152.$$

$$K_h = 55.564 \text{ kN/m}^3$$



$$\text{paal } \nabla 600 \text{ mm} \rightarrow D_{eq} = \sqrt{9,6^2 / \pi} \times 2 = 0,67702 \text{ m.}$$
$$R = 0,33851 \text{ m}$$

Material : Zand.

$$\alpha : 0,33$$

$$\beta : 0,85$$

$$q_c : 12 \text{ MPa}$$

$$E_m = \beta \times q_c = 0,85 \times 12 = 10,2 \text{ MPa} = 10,2 \cdot 10^3 \text{ kN/m}^2$$

K_h indien $R \geq R_0$ ($R_0 = 0,3$)

$$\frac{1}{K_h} = \frac{1}{3 E_m} \times \left(1,3 \times R_0 \times \left(\frac{2,65 \times R}{R_0} \right)^\alpha + \alpha \times R \right)$$

$$\frac{1}{K_h} = \frac{1}{3 \times 10,2 \cdot 10^3} \times \left(1,3 \times 0,3 \times \left(\frac{2,65 \times 0,33851}{0,3} \right)^{0,33} + 0,33 \times 0,33851 \right)$$

$$\frac{1}{K_h} = 3,2679 \cdot 10^{-5} \times (0,55901 + 0,11171)$$

$$K_h = 45.569 \text{ kN/m}^3$$



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Appendix 2: spread sheet calculations



Project name: Validation
Project number: Part:
 Engineer: R. Thijssen Date: 1-8-2012 Version: Dako Software
Part: Calculation of horizontal moduli of subgrade reaction for piles according to Ménard
 General multiplier: 1.00
 Comments:

Pile type: Rectangular Width: 0.45 [m] D.equi: 0.508 [m] Soil Type: Sand
 Bottom [m NAP]: -1 Top [m NAP]: 0
 Condition: Normally Consolidated
 α : 0.33 β : 0.85 Q_e [Mpa]: 12 E_m [Mpa]: 10.2
 Multiplier: 1
 Best estimate: kh [kN/m³]: 55540
 Lower bound (x 0,71): kh [kN/m³]: 39430
 Upper bound (x 1,41): kh [kN/m³]: 78310

Overview calculation results for a SINGLE PILE.

Layer no.	Name	Top [m NAP]	Bottom [m NAP]	Soil Type	Condition	β	α	Q_e [Mpa]	Multiplier	E_m [Mpa]	Best estimate kh [kN/m ³]	Upper bound (x 1,41) kh [kN/m ³]	Lower bound (x 0,71) kh [kN/m ³]
1	n.c., qe = 1	0	-1	Sand	Normally Consolidated	0.85	0.33	12	1	10.2	55540	78310	39430

Overview calculation results for a PILE GROUP side by side piles, after Reese & Van Impe

NOT APPLICABLE

Layer no.	Name	Top [m NAP]	Bottom [m NAP]	Multiplier	Best estimate kh [kN/m ³]	Upper bound (x 1,41) kh [kN/m ³]	Lower bound (x 0,71) kh [kN/m ³]
1	n.c., qe = 12	0	-1	1.0	55540	78310	39430

c.t.c. distance piles perpendicular to loading (S):
m

Multiplier kh pile group:
1.00



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Project name: Validation **Part:**

Project number: R. Thijssen Date: 1-8-2012 Version: **Calculation of horizontal moduli of subgrade reaction for piles according to Ménard**

Pile type Rectangular Width 0.6 [m] General multiplier 1.00
 D,equi 0.678 [m] Comments:

Overview calculation results for a SINGLE PILE.

Layer no.	Name	Top [m NAP]	Bottom [m NAP]	Soil Type	Condition	β	α	Qe [Mpa]	Multiplier	Em [Mpa]	Lower bound (x 0.71) kh [kN/m ³]	Best estimate kh [kN/m ³]	Upper bound (x 1.41) kh [kN/m ³]
1	n.c., qe = 1	0	-1	Sand	Normally Consolidated	0.85	0.33	12	1	10.2	32330	45540	64210

Overview calculation results for a PILE GROUP side by side piles, after Reese & Van Impe

c.c.c. distance piles perpendicular to loading (S):
m

Layer no.	Name	Top [m NAP]	Bottom [m NAP]	Multiplier	Lower bound (x 0.71) kh [kN/m ³]	Best estimate kh [kN/m ³]	Upper bound (x 1.41) kh [kN/m ³]
1	n.c., qe = 12	0	-1	1.0	32330	45540	64210

Multiplier kh pile group:
1.00

NOT APPLICABLE