Contents

DOING IT RIGHT.

1. Scope of Works / Description of Systems of Plant & Equipment

POYLE

Horton Road

Ground improvement by Vibro Stone Columns (VSC)

DESIGN REPORT

Reference	V29669	Pages	12

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1. INTRODUCTION

It is proposed to construct to construct a single storey warehouse on Horton Road, Poyle. The proposed construction footprint runs over made ground, underlain by soft Alluvium, Shepperton Gravel Member, then followed by London Clay.

Due to the presence of made ground and soft alluvium, a direct construction of any type of structure without soil improvement or replacement will lead to unacceptable post construction settlements and deformations.

The concerned structures are **the pad/strip footings and ground bearing slabs of the entire Unit 100 covering a total area of around 7,150 m2.**

These structures are shown in red in the figure below.

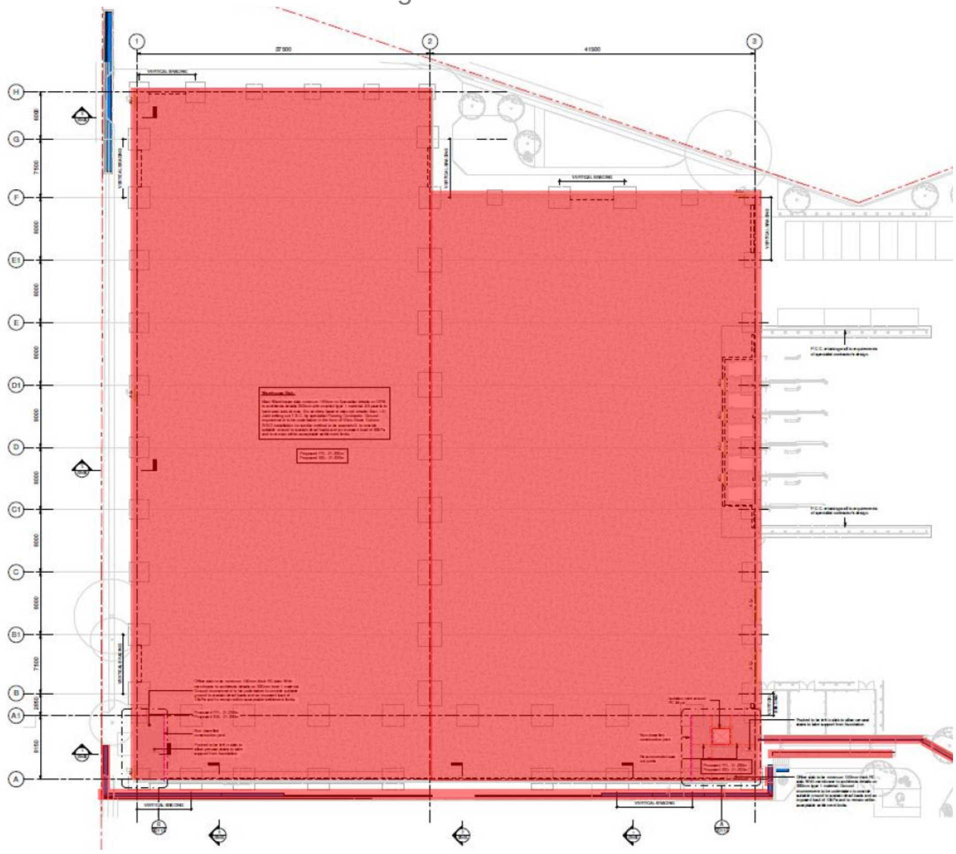

Figure 1 - Site layout with VSC treatment area in red

The present document consists in a design report for ground improvement with **the Vibro Stone Columns (VSC)** technique. The aim of the VSC solution is to control the settlements and provide a higher bearing capacity by creating a composite material [VSC+soil].

3. TECHNICAL

3.1. Description of the ground improvement technique

Vibro Stone Columns are formed by inserting a vibroprobe into the soils to compact and incorporate granular material into the ground and create vertical inclusions with high stiffness, shear strength and drainage characteristics.

Under uniformly loaded structures such as embankments and slabs-on-grade, Vibro Stone Columns are installed on a regular grid spacing. Treatment by Vibro Stone Columns results in a reduction of the total and differential settlements.

Vibro Stone Columns can also be installed as a group to support isolated loads (shallow pads) or directly under linear loadings such as strip footing or retaining walls. In this case, Vibro Stone Columns increase the bearing capacity of the soil while reducing the magnitude of settlement.

3.2. Method of execution

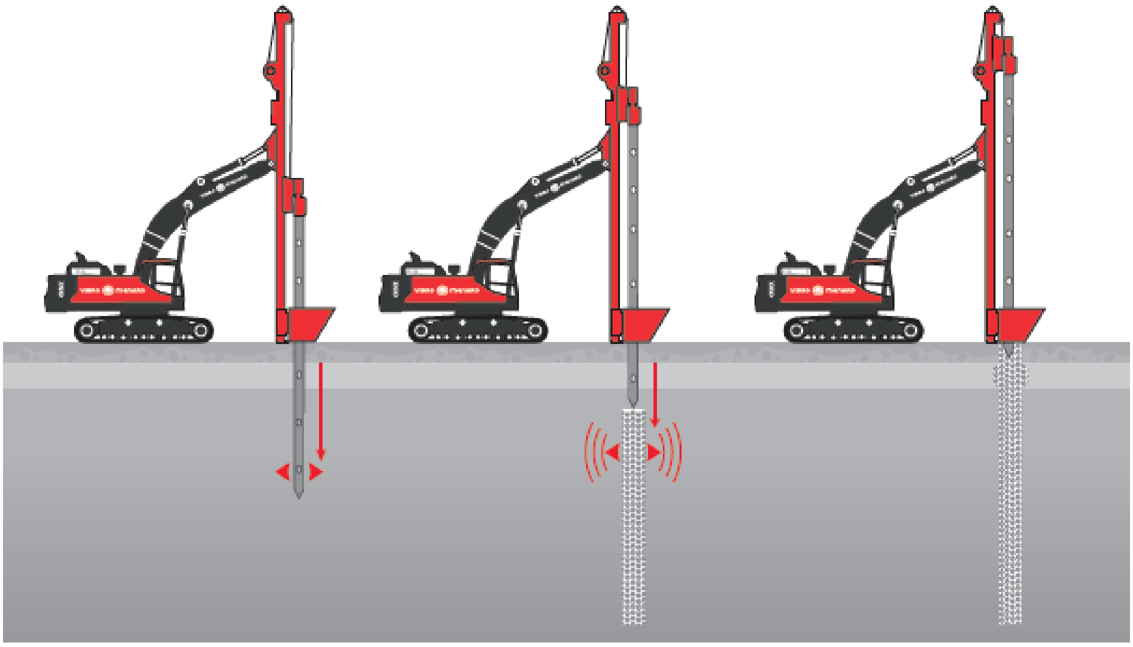

Figure 2 - VSC installation process

The soil is penetrated to the required depth by the combined effects of vibroprobe weight and vibration (plus jetting action by air if free hanging). The in-situ soil is displaced sideways.

The vibroprobe is then lifted out. Coarse gravel, crushed stone or slag is tipped into the hole in increments of typically 500 mm of the column bore. The vibroprobe is re-inserted and the stone infill is compacted under the weight and vibration of the vibroprobe. Radial forces produced by the vibroprobe force the stone infill material horizontally out against the in-situ soil.

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When the required degree of compaction has been reached, the vibroprobe is again removed. The filling / compacting cycle is repeated step by step up to the working platform level. Thus, a continuous column of dense granular material interlocking with the surrounding ground is formed through the treatment zone.

Depending on the ground conditions, the stones can be inserted from the top of the platform (Top Feed) or from the bottom of the hole (Bottom Feed). The typical material used for the installation of Vibro Stone Columns is granular material (ballast, gravels) in the particle size range 10/40 for the bottom feed process and 20/75 for the top feed process.

Figure 3 - VSC rig on site (Top Feed – left, Bottom Feed – right)

3.3. Adaptation to the project

3.3.1. Ground improvement principle

The foreseen ground reinforcement system consists in installing vertical Vibro Stone Columns (VSC) beneath the foundations and ground bearing slab in order to create a composite material [soil+VSC] and therefore increase the bearing capacity of the soil and reduce long term settlements to within acceptable limits.

3.3.2. Characteristics of the VSC solution

The characteristics of the VSC for this project will be:

Anticipated VSC diameter* [m]	Young's Modulus E_Y [MPa]	Unit Weight γ [kN/m^3]	Friction Angle φ [°]
0.40	50	20	38

Table 1 - VSC characteristics

**The diameter of the VSC depends on the properties of the surrounding soil and as such, over the length of the entire VSC, variable diameters could be created due to variable layers with different soil conditions.*

4. GROUND CONDITIONS

Our design is based on the ground conditions described in the above site investigation report [2]. The ground conditions are homogeneous over the site.

The typical soil profile is the following:

- Made Ground
- Soft Alluvium
- Medium dense to dense Shepperton Gravel Member
- Stiff London Clay below

The calculations were carried out for the conservative soil profile detailed in the table below. All the values of the design parameters have been derived from correlations based on N_{SPT}.

	Top	Bottom	γ	N_{SPT}	p_l	E_Y	ν
	(mbgl)	(mbgl)	(kN/m^3)	(MPa)	(MPa)	(MPa)	(-)
Made Ground (Loose sand)	0	0.8	18	10	0.50	6	0.33
Alluvium	0.8	1.5	18	8	0.40	6	0.33
Shepperton Gravel Member	1.5	3.5	18	30	1.50	60	0.33
London Clay	3.5	-	18	10	0.67	30	0.33
VSC	Var	1.5	18	-	-	50	0.33

Table 2 - Soil profile and geotechnical parameters

Notes:

- The level '0' corresponds to the working platform level, expected to be around +20.770 mAOD.
- VSC will go through the made ground and soft Alluvium. As such, their depth is expected to be about 1 to 2m from the working platform level.
- The symbols used in the table above are: γ = bulk unit weight, N_{SPT} = SPT blow count, E_Y = Young's modulus, p_l = pressure limit, ν = Poisson's ratio.
- The ground water level was encountered at 1.5 mbgl during the site investigation.

5. CALCULATIONS RESULTS

5.1. Footings

The calculations of the ground improvement beneath the footings are carried out using the Priebe method, considering **a bearing pressure of 150 kPa,** for each pad type. The results are summarized in the table below and the details of the calculations are presented in Appendix 1 for some selected cases.

Pad Type	Length	Width	SLS bearing pressure	SLS vertical load	No of VSC	Settlement
(-)	(m)	(m)	(kPa)	(kN)	(-)	(mm)
A	2.0	2.0	150	600	2	8
B	2.5	2.5	150	937.5	4	9
C	3.8	5.2	150	2964	10	13
D	3.6	3.6	150	1944	7	12
E	3.9	3.9	150	2281.5	8	12
F	2.9	2.9	150	1261.5	5	10
G	4.5	4.5	150	3037.5	11	13
H	3.6	3.6	150	1944	7	11
J	4.0	4.0	150	2400	8	12
K	1.0	1.0	150	150	1	5
L	3.8	3.8	150	2166	8	11
M	2.9	4.5	150	1957.5	7	12
N	0.45	0.45	150	30.375	1	2
X	3.6	4.0	150	2160	8	12

Table 3 - Design results for pad footings

Strip Type	Width	SLS bearing pressure	SLS vertical load	No of VSC	Settlement
(-)	(m)	(kPa)	(kN/lm)	(-)	(mm)
Dock Leveller	1.5	100	150	1 every 2m	11
Retaining Wall	1.7	150	255	1 every 1.17m	13

Table 4 - Design results for strip footings

Conclusion: **The settlements under the working loads remain acceptable (< 25 mm).**

5.2. Ground bearing slab

Calculations of the ground improvement under the ground bearing slab are carried out using the Priebe method considering a **UDL of 50 kPa.** The results are summarized in the table below and the details of the calculations are presented in Appendix 2.

Zone	SLS UDL	VSC Grid	Settlement
(-)	(kPa)	(m x m)	(mm)
-	50	3 x 3	16

Table 5 - Calculation results for ground bearing slab

Conclusion: **The settlements under the working loads remain acceptable (< 25 mm).**

6. QUALITY CONTROL

6.1. Monitoring and recording

- Layout drawing showing the location of each VSC will be produced by Vibro Menard.
- Calibration drilling(s) close to existing soil investigation borehole(s) to calibrate drilling parameters to each layer of the geotechnical profile and to define a "refusal" criteria will be done.
- The work done is also recorded by a log of each columns showing the column reference number, penetration length, stone quantity and a note of any unusual circumstances encountered during the installation (depth of predrilling, refusals, etc.). This log will be recorded on our standard Daily Record Sheet and handed to the Engineer daily.

6.2. Testing

We propose to check the quality of our Vibro Stone Column work by Plate Load Tests as described below. We have included for **7 plate load tests** on this project.

Our standard Plate Load Test comprises a 0.6 m diameter plate which is positioned centrally over a compaction point on a layer of sand at a depth of approximately 0.6m below working surface. The load is applied centrally to the plate by a calibrated hydraulic jack.

The plate is carefully bedded onto the compaction point by means of a small pre-load of 2.0 tones which is immediately released. The stage loading will then be applied in 2.0 tons increments up to 3 times the particular design bearing pressure calculated over the area of the plate or to a maximum of 11.0 tons whichever is the least.

Deflections of the plate will be measured by dial gauges supported independently and remote from the test area. Unloading is carried out in a single stage and recovery recorded. The total duration of each test will not exceed 1 hour.

In cohesive soils relatively high settlements of the plate may be recorded due to temporary increase in pore water pressure. Also, tests are not usually undertaken between stone columns. The results of tests in clay soils cannot be used as failure criteria for our work.

7. CONCLUSION

The design for ground improvement by Vibro Stone Columns (VSC) below the concerned structures (**pad footings and ground bearing slabs of entire building**) has been carried out using the Priebe method. The calculation results show that the VSC solution achieves **acceptable residual settlement values under the footings and slabs (< 25 mm).**

The Vibro Stone Columns will be installed with a number of VSC varying from **1 to 11 below the pads. Beneath the slab,** the VSC will be arranged according to a **spacing of maximum 3 m x 3 m.**

The VSC will be installed through the made ground and soft alluvium. As such, **their depth is expected to be about 1 to 2 m from the Working Platform Level at 20.770 mAOD.**

2. Suppliers and Manufacturers Directory

N/A

3. Manufacturers Information

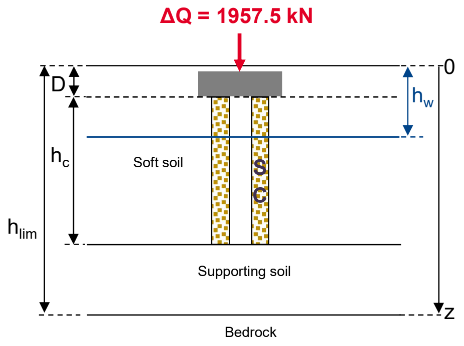
APPENDIX 1: DETAILED CALCULATIONS BENEATH THE FOOTINGS

Project name: Poyle pad @150kPa
2.9m x 4.5m pad (M)

Area of the rectangular footing: 2.90 m x 4.50 m **Footing loaded at** ΔQ = 1,957.5 kN

DESIGN AS PER PRIEBE METHOD

Presentation of the model and main calculation results



Area of the footing =	13.05 m²
Diameter of the columns =	0.4 m to 0.4 m
Total settlement =	1.2 cm
Maximal stress within the columns =	622.8 kPa

Description of Stone Columns reinforcement

Description of the footing

Type of footing: **Rectangular**

L	2.9 m	*Length of the footing*		d	1.2 m	*Embedment height*
B	4.5 m	*Width of the footing*		$A_{footing}$	13.05 m²	*Area of the footing*

Number of columns under the footing: 7

Description of the stone columns

A	1.86 m²	*Equivalent grid area of the columns*		γ_c	20 kN/m³	*Unit weight of the gravel*
h_c	0.4 m	*Length of the columns*		φ_c	38 °	*Friction angle of the gravel*
E_c	50,000 kPa	*Young's modulus*		Ka_c	0.24	*Coefficient of active earth pressure*
ν_c	0.33	*Poisson's coefficient*		K_{0c}	0.38	*Coefficient of earth pressure at rest*
M_c	75,000 kPa	*Oedometric modulus*				

Description of natural soil surrounding the columns

h_w 1.5 m *Depth of Ground Water Table*

Priebe considers: $K_{0s} = 1$ *with K_{0s} : coefficient of earth pressure at rest*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	ν_s (-)	γ_s (kN/m³)	M_s (kPa)	$Ø_c$ (m)	τ (%)	p_l* (kPa)
1	1.2	1.2	6,000	0.33	18	9,000	0.40	6.7%	400
2	1.2	1.3	6,000	0.33	18	9,000	0.40	6.7%	400
3	1.3	1.3	6,000	0.33	18	9,000	0.40	6.7%	400
4	1.3	1.4	6,000	0.33	18	9,000	0.40	6.7%	400
5	1.4	1.4	6,000	0.33	18	9,000	0.40	6.7%	400
6	1.4	1.4	6,000	0.33	18	9,000	0.40	6.7%	400
7	1.4	1.5	6,000	0.33	18	9,000	0.40	6.7%	400
8	1.5	1.5	6,000	0.33	18	9,000	0.40	6.7%	400
9	1.5	1.6	6,000	0.33	18	9,000	0.40	6.7%	400
10	1.6	1.6	6,000	0.33	18	9,000	0.40	6.7%	400

Description of natural soil below the columns

h_{lim} 10.0 m *Limit depth of model*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	ν_s (-)	M_s (kPa)
11	1.6	3.5	60,000	0.33	90,000
12	3.5	10.0	30,000	0.33	45,000

Notations

z_{sup}	*Depth of the top of the soil layer*	M_s	*Oedometric modulus in the layer*
z_{inf}	*Depth of the bottom of the soil layer*	$Ø_c$	*Stone Columns' diameter*
E_s	*Young's modulus in the layer*	τ	*Replacement ratio*
ν_s	*Poisson's coefficient*	p_l*	*Limit pressure in the layer*
γ_s	*Unit weight of the soil layer*		

Loading description at SLS

ΔQ	1,958 kN	*Load applied at the footing base*
Δq	150.0 kPa	*Pressure applied at the footing base*

UNIFORM LOADING

Hypothesis: columns are not compressible

Priebe suggests to use the following settlement reduction ratio, corresponding to an incompressible gravel:

$$\beta = 1 + \tau\left(\frac{f(\nu_s,\tau) + \frac{1}{2}}{f(\nu_s,\tau).K_{a_c}} - 1\right)$$

With:

$$f(\nu_s,\tau) = \frac{1-\nu_s^2}{1-\nu_s-2\nu_s^2}.\frac{(1-2\nu_s)(1-\tau)}{1-2\nu_s+\tau}$$

Values of the settlement reduction ratio, first step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	$f_0(\nu_s,\tau)$ (-)	β_0 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.2	1.2	1.55	1.3	114.7	637.8
2	1.2	1.3	1.55	1.3	114.7	637.8
3	1.3	1.3	1.55	1.3	114.7	637.8
4	1.3	1.4	1.55	1.3	114.7	637.8
5	1.4	1.4	1.55	1.3	114.7	637.8
6	1.4	1.4	1.55	1.3	114.7	637.8
7	1.4	1.5	1.55	1.3	114.7	637.8
8	1.5	1.5	1.55	1.3	114.7	637.8
9	1.5	1.6	1.55	1.3	114.7	637.8
10	1.6	1.6	1.55	1.3	114.7	637.8

Stress in soil and columns is assessed using the following formula:

$$\beta_0 = \frac{\Delta q}{\Delta q_s}$$

$$\Delta q = \tau.\Delta q_c + (1-\tau).\Delta q_s$$

Notations

Δq_s	*Additional stress on the soil*
Δq_c	*Additional stress in the column*

Column are made of compressible material

To take into account the fact that gravel is compressible, one should modify the replacement ratio value using the compressibility ratio column / soil.

Values of the settlement reduction ratio, second step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	M_c/M_s (-)	$\Delta(1/\tau)$ (-)	$\tau_{corrected}$ (%)	$f(\nu_s,\tau_{corrected})$ (-)	β_1 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.2	1.2	8.3	0.58	6.5%	1.57	1.3	115.8	622.8
2	1.2	1.3	8.3	0.58	6.5%	1.57	1.3	115.8	622.8
3	1.3	1.3	8.3	0.58	6.5%	1.57	1.3	115.8	622.8
4	1.3	1.4	8.3	0.58	6.5%	1.57	1.3	115.8	622.8
5	1.4	1.4	8.3	0.58	6.5%	1.57	1.3	115.8	622.8
6	1.4	1.4	8.3	0.58	6.5%	1.57	1.3	115.8	622.8
7	1.4	1.5	8.3	0.58	6.5%	1.57	1.3	115.8	622.8
8	1.5	1.5	8.3	0.58	6.5%	1.57	1.3	115.8	622.8
9	1.5	1.6	8.3	0.58	6.5%	1.57	1.3	115.8	622.8
10	1.6	1.6	8.3	0.58	6.5%	1.57	1.3	115.8	622.8

Notations

$\Delta(1/\tau)$	*Increase of 1 / τ*
$\tau_{corrected}$	*Modified value of replacement ratio*

Stress distribution per improved layer

The stress distribution ratio is:

$$n = \frac{\Delta q_C}{\Delta q_S} = \frac{f(\nu_s,\tau_{corrected}) + \frac{1}{2}}{f(\nu_s,\tau_{corrected}) \cdot K_{a_c}}$$

Layer n°	z_{sup} (m)	z_{inf} (m)	n (-)	$q_{c,0}$ (kPa)	Δq_c (kPa)	q_c (kPa)	$\Delta q_{c,max}$ (kPa)	Checking against bulging failure	$q_{s,0}$ (kPa)	Δq_s (kPa)	q_s (kPa)
1	1.2	1.2	5.5	22.0	622.8	644.8	800.0	OK	22.0	115.8	137.8
2	1.2	1.3	5.5	22.8	622.8	645.6	800.0	OK	22.7	115.8	138.5
3	1.3	1.3	5.5	23.6	622.8	646.4	800.0	OK	23.4	115.8	139.2
4	1.3	1.4	5.5	24.4	622.8	647.2	800.0	OK	24.1	115.8	139.9
5	1.4	1.4	5.5	25.2	622.8	648.0	800.0	OK	24.8	115.8	140.7
6	1.4	1.4	5.5	26.0	622.8	648.8	800.0	OK	25.6	115.8	141.4
7	1.4	1.5	5.5	26.8	622.8	649.6	800.0	OK	26.3	115.8	142.1
8	1.5	1.5	5.5	27.5	622.8	650.3	800.0	OK	26.9	115.8	142.7
9	1.5	1.6	5.5	28.0	622.8	650.8	800.0	OK	27.3	115.8	143.1
10	1.6	1.6	5.5	28.4	622.8	651.2	800.0	OK	27.6	115.8	143.5

Notations

$q_{c,0}$	*Initial effective vertical stress in the column*
q_c	*Final effective vertical stress in the column*
$\Delta q_{c,max}$	*Limit value as per DTU 13-2 (Fs = 2)*
$q_{s,0}$	*Initial effective vertical stress in the soil*
q_s	*Final effective vertical stress in the soil*

Depth correction factor

To take into account the additional lateral constraint due the earth pressure at depth, the settlement reduction ratio is multiplied by a coefficient f_d.

$$\beta_2 = f_d . \beta_1 \quad \text{and} \quad f_d = \frac{1}{1 + \frac{K_{0_c} - \frac{q_{s,0}}{q_{c,0}}}{K_{0_c}} . \frac{q_{c,0}}{\Delta q_c}} \quad \text{with} \quad f_d \geq 1$$

The coefficient f_d is limited by following formula:

$$f_d \leq \frac{M_c}{M_s} . \frac{\Delta q_s}{\Delta q_c}$$

The settlement reduction ratio β_2 is limited by:

$$\beta_{2,max} = 1 + \tau\left(\frac{M_c}{M_s} - 1\right)$$

Values of the settlement reduction ratio, step 3, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	f_d (-)	$f_{d,max}$ (-)	f_d (-)	β_2 (-)	$\beta_{2,max}$ (-)	β_2 (-)
1	1.2	1.2	1.1	1.5	1.1	1.4	1.5	1.4
2	1.2	1.3	1.1	1.5	1.1	1.4	1.5	1.4
3	1.3	1.3	1.1	1.5	1.1	1.4	1.5	1.4
4	1.3	1.4	1.1	1.5	1.1	1.4	1.5	1.4
5	1.4	1.4	1.1	1.5	1.1	1.4	1.5	1.4
6	1.4	1.4	1.1	1.5	1.1	1.4	1.5	1.4
7	1.4	1.5	1.1	1.5	1.1	1.4	1.5	1.4
8	1.5	1.5	1.1	1.5	1.1	1.4	1.5	1.4
9	1.5	1.6	1.1	1.5	1.1	1.4	1.5	1.4
10	1.6	1.6	1.1	1.5	1.1	1.4	1.5	1.4

Settlement distribution per layer

Over the length of the columns

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)	S_a (m)
1	1.2	1.2	0.001	0.000
2	1.2	1.3	0.001	0.000
3	1.3	1.3	0.001	0.000
4	1.3	1.4	0.001	0.000
5	1.4	1.4	0.001	0.000
6	1.4	1.4	0.001	0.000
7	1.4	1.5	0.001	0.000
8	1.5	1.5	0.001	0.000
9	1.5	1.6	0.001	0.000
10	1.6	1.6	0.001	0.000
		TOTAL	**0.007**	**0.005**

Notations

S_{na} *Settlement of soil without soil improvement*

S_a *Settlement of soil with soil improvement*

The total settlement in the soil w/o improvement under an uniform load is: 0.7 cm

The settlement decrease ratio under an uniform load is: 1.4

The total settlement of the improved soil under an uniform load is: 0.5 cm

Below the improved soil layers

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)
11	1.6	3.5	0.003
12	3.5	10.0	0.022
		TOTAL	**0.025**

The settlement below the improved soil layers is: 2.5 cm

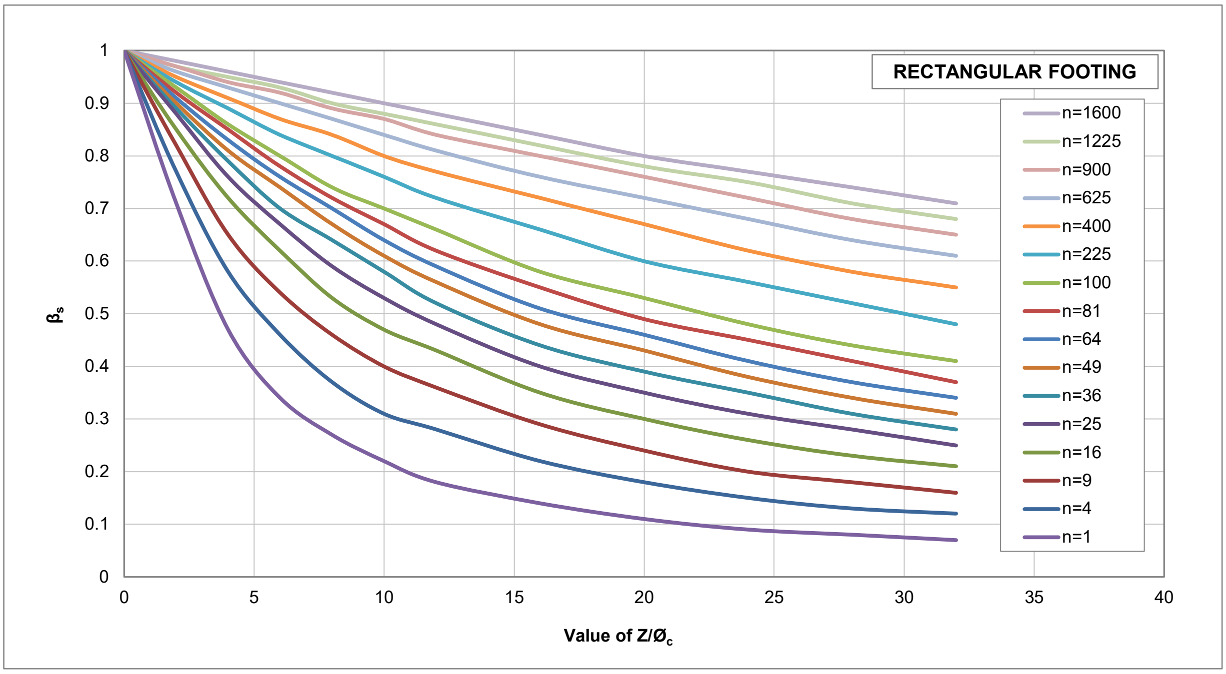
THE TOTAL SETTLEMENT OF THE SOIL UNDER AN UNIFORM LOAD IS 3.0 cm

LOADING ON THE FOOTING

Settlement distribution

Over the length of the columns

This calculation is made by applying a new settlement reduction factor β_s to the settlement of the soil improved by stone columns.
Priebe has given a diagram of β_s values depending on the depth/diameter ratio $z/Ø_c$ and number of Stone Columns n.



The number of columns below the footing is: 7

The settlement of a layer at a depth Z below the base of the footing is determined as the difference of the settlements calculated between the lower bound Z_{inf} and the upper bound Z_{sup} of the concerned layer, with an average β_s calculated over the thickness of this layer:

$$S_{a,s}(z) = \frac{\Delta q}{M_s \beta_2}\left[(\beta_s)_{inf} . Z_{inf} - (\beta_s)_{sup} . Z_{sup}\right]$$

Layer n°	z sup (m)	z inf (m)	Z sup (m)	Z inf (m)	Z sup/Ø c (-)	Z inf/Ø c (-)	(β s) sup (-)	(β s) inf (-)	S a,s (m)
1	1.2	1.2	0.0	0.0	0.00	0.10	1.00	0.99	0.000
2	1.2	1.3	0.0	0.1	0.10	0.20	0.99	0.98	0.000
3	1.3	1.3	0.1	0.1	0.20	0.30	0.98	0.97	0.000
4	1.3	1.4	0.1	0.2	0.30	0.40	0.97	0.96	0.000
5	1.4	1.4	0.2	0.2	0.40	0.50	0.96	0.95	0.000
6	1.4	1.4	0.2	0.2	0.50	0.60	0.95	0.94	0.000
7	1.4	1.5	0.2	0.3	0.60	0.70	0.94	0.93	0.000
8	1.5	1.5	0.3	0.3	0.70	0.80	0.93	0.92	0.000
9	1.5	1.6	0.3	0.4	0.80	0.90	0.92	0.91	0.000
10	1.6	1.6	0.4	0.4	0.90	1.00	0.91	0.90	0.000
								TOTAL	0.004

The total settlement of the improved soil under the footing is: 0.4 cm

Notations

Z_{sup}	*Depth of the top of the soil layer from the foundation base*	$(\beta_s)_{sup}$	*Settlement reduction factor at the level of z_{sup}*
Z_{inf}	*Depth of the bottom of the soil layer from the foundation base*	$(\beta_s)_{inf}$	*Settlement reduction factor at the level of z_{inf}*
$S_{a,s}$	*Settlement of soil with soil improvement*		

Below the improved soil layers

Layer n°	z sup (m)	z inf (m)	S na,s (m)
11	1.6	3.5	0.003
12	3.5	10.0	0.005
		TOTAL	0.007

The settlement below the improved soil layers is: 0.7 cm

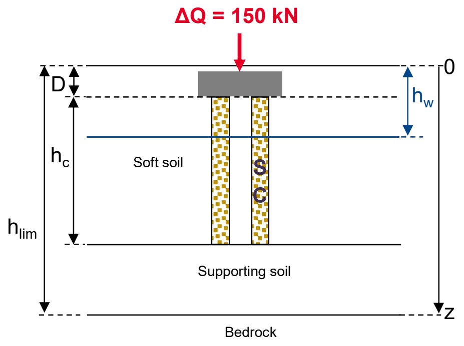
THE TOTAL SETTLEMENT OF THE SOIL BELOW THE FOOTING IS 1.2 cm

Project name: **Poyle pad @150kPa**
1.0m x 1.0m pad (K)

Area of the rectangular footing: 1.00 m x 1.00 m **Footing loaded at** ΔQ = 150.0 kN

DESIGN AS PER PRIEBE METHOD

Presentation of the model and main calculation results



Area of the footing =	1 m²		
Diameter of the columns =	0.4 m	to	0.4 m
Total settlement =	0.5 cm		
Maximal stress within the columns =			526.3 kPa

Description of Stone Columns reinforcement

Description of the footing

Type of footing: **Rectangular**

L	1 m	*Length of the footing*	d	1.1 m	*Embedment height*
B	1 m	*Width of the footing*	$A_{footing}$	1 m²	*Area of the footing*

Number of columns under the footing: 1

Description of the stone columns

A	1.00 m²	*Equivalent grid area of the columns*	γ_c	20 kN/m³	*Unit weight of the gravel*
h_c	0.4 m	*Length of the columns*	φ_c	38 °	*Friction angle of the gravel*
E_c	50,000 kPa	*Young's modulus*	Ka_c	0.24	*Coefficient of active earth pressure*
v_c	0.33	*Poisson's coefficient*	K_{0c}	0.38	*Coefficient of earth pressure at rest*
M_c	75,000 kPa	*Oedometric modulus*			

Description of natural soil surrounding the columns

h_w 1.5 m *Depth of Ground Water Table*

Priebe considers: $K_{0s} = 1$ *with* K_{0s} *: coefficient of earth pressure at rest*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	v_s (-)	γ_s (kN/m³)	M_s (kPa)	$Ø_c$ (m)	τ (%)	p_l* (kPa)
1	1.1	1.1	6,000	0.33	18	9,000	0.40	12.6%	400
2	1.1	1.2	6,000	0.33	18	9,000	0.40	12.6%	400
3	1.2	1.2	6,000	0.33	18	9,000	0.40	12.6%	400
4	1.2	1.3	6,000	0.33	18	9,000	0.40	12.6%	400
5	1.3	1.3	6,000	0.33	18	9,000	0.40	12.6%	400
6	1.3	1.3	6,000	0.33	18	9,000	0.40	12.6%	400
7	1.3	1.4	6,000	0.33	18	9,000	0.40	12.6%	400
8	1.4	1.4	6,000	0.33	18	9,000	0.40	12.6%	400
9	1.4	1.5	6,000	0.33	18	9,000	0.40	12.6%	400
10	1.5	1.5	6,000	0.33	18	9,000	0.40	12.6%	400

Description of natural soil below the columns

h_{lim} 10.0 m *Limit depth of model*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	v_s (-)	M_s (kPa)
11	1.5	3.5	60,000	0.33	90,000
12	3.5	10.0	30,000	0.33	45,000

Notations

z_{sup}	*Depth of the top of the soil layer*	M_s	*Oedometric modulus in the layer*
z_{inf}	*Depth of the bottom of the soil layer*	$Ø_c$	*Stone Columns' diameter*
E_s	*Young's modulus in the layer*	τ	*Replacement ratio*
v_s	*Poisson's coefficient*	p_l*	*Limit pressure in the layer*
γ_s	*Unit weight of the soil layer*		

Loading description at SLS

ΔQ	150	kN	*Load applied at the footing base*
Δq	150.0	kPa	*Pressure applied at the footing base*

UNIFORM LOADING

Hypothesis: columns are not compressible

Priebe suggests to use the following settlement reduction ratio, corresponding to an incompressible gravel:

$$\beta = 1 + \tau\left(\frac{f(\nu_s, \tau) + \frac{1}{2}}{f(\nu_s, \tau).K_{a_c}} - 1\right)$$

With:

$$f(\nu_s, \tau) = \frac{1 - \nu_s^2}{1 - \nu_s - 2\nu_s^2} \cdot \frac{(1 - 2\nu_s)(1 - \tau)}{1 - 2\nu_s + \tau}$$

Values of the settlement reduction ratio, first step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	$f_0(v_s,\tau)$ (-)	β_0 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.1	1.1	1.27	1.6	93.1	545.7
2	1.1	1.2	1.27	1.6	93.1	545.7
3	1.2	1.2	1.27	1.6	93.1	545.7
4	1.2	1.3	1.27	1.6	93.1	545.7
5	1.3	1.3	1.27	1.6	93.1	545.7
6	1.3	1.3	1.27	1.6	93.1	545.7
7	1.3	1.4	1.27	1.6	93.1	545.7
8	1.4	1.4	1.27	1.6	93.1	545.7
9	1.4	1.5	1.27	1.6	93.1	545.7
10	1.5	1.5	1.27	1.6	93.1	545.7

Stress in soil and columns is assessed using the following formula:

$$\beta_0 = \frac{\Delta q}{\Delta q_s}$$

$$\Delta q = \tau.\Delta q_c + (1 - \tau).\Delta q_s$$

Notations

Δq_s	*Additional stress on the soil*
Δq_c	*Additional stress in the column*

Column are made of compressible material

To take into account the fact that gravel is compressible, one should modify the replacement ratio value using the compressibility ratio column / soil.

Values of the settlement reduction ratio, second step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	M_c/M_s (-)	$\Delta(1/\tau)$ (-)	$\tau_{corrected}$ (%)	$f(v_s,\tau_{corrected})$ (-)	β_1 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.1	1.1	8.3	0.58	11.7%	1.31	1.6	95.9	526.3
2	1.1	1.2	8.3	0.58	11.7%	1.31	1.6	95.9	526.3
3	1.2	1.2	8.3	0.58	11.7%	1.31	1.6	95.9	526.3
4	1.2	1.3	8.3	0.58	11.7%	1.31	1.6	95.9	526.3
5	1.3	1.3	8.3	0.58	11.7%	1.31	1.6	95.9	526.3
6	1.3	1.3	8.3	0.58	11.7%	1.31	1.6	95.9	526.3
7	1.3	1.4	8.3	0.58	11.7%	1.31	1.6	95.9	526.3
8	1.4	1.4	8.3	0.58	11.7%	1.31	1.6	95.9	526.3
9	1.4	1.5	8.3	0.58	11.7%	1.31	1.6	95.9	526.3
10	1.5	1.5	8.3	0.58	11.7%	1.31	1.6	95.9	526.3

Notations

$\Delta(1/\tau)$	*Increase of 1 / τ*
$\tau_{corrected}$	*Modified value of replacement ratio*

Stress distribution per improved layer

The stress distribution ratio is:

$$n = \frac{\Delta q_C}{\Delta q_S} = \frac{f(\nu_s, \tau_{corrected}) + \frac{1}{2}}{f(\nu_s, \tau_{corrected}) \cdot K_{a_c}}$$

Layer n°	z_{sup} (m)	z_{inf} (m)	n (-)	$q_{c,0}$ (kPa)	Δq_c (kPa)	q_c (kPa)	$\Delta q_{c,max}$ (kPa)	Checking against bulging failure	$q_{s,0}$ (kPa)	Δq_s (kPa)	q_s (kPa)
1	1.1	1.1	5.8	20.2	526.3	546.5	800.0	OK	20.2	95.9	116.1
2	1.1	1.2	5.8	21.0	526.3	547.3	800.0	OK	20.9	95.9	116.8
3	1.2	1.2	5.8	21.8	526.3	548.1	800.0	OK	21.6	95.9	117.5
4	1.2	1.3	5.8	22.6	526.3	548.9	800.0	OK	22.3	95.9	118.2
5	1.3	1.3	5.8	23.4	526.3	549.7	800.0	OK	23.0	95.9	118.9
6	1.3	1.3	5.8	24.2	526.3	550.5	800.0	OK	23.8	95.9	119.7
7	1.3	1.4	5.8	25.0	526.3	551.3	800.0	OK	24.5	95.9	120.4
8	1.4	1.4	5.8	25.8	526.3	552.1	800.0	OK	25.2	95.9	121.1
9	1.4	1.5	5.8	26.6	526.3	552.9	800.0	OK	25.9	95.9	121.8
10	1.5	1.5	5.8	27.4	526.3	553.7	800.0	OK	26.6	95.9	122.5

Notations

$q_{c,0}$	*Initial effective vertical stress in the column*	$q_{s,0}$	*Initial effective vertical stress in the soil*
q_c	*Final effective vertical stress in the column*	q_s	*Final effective vertical stress in the soil*
$\Delta q_{c,max}$	*Limit value as per DTU 13-2 (Fs = 2)*		

Depth correction factor

To take into account the additional lateral constraint due the earth pressure at depth, the settlement reduction ratio is multiplied by a coefficient f_d.

$$\beta_2 = f_d . \beta_1$$ *and* $$f_d = \frac{1}{1 + \frac{K_{0_c} - \frac{q_{s,0}}{q_{c,0}}}{K_{0_c}} . \frac{q_{c,0}}{\Delta q_c}}$$ *with* $f_d \geq 1$

The coefficient f_d is limited by following formula: $$f_d \leq \frac{M_c}{M_s} . \frac{\Delta q_s}{\Delta q_c}$$

The settlement reduction ratio β_2 is limited by: $$\beta_{2,max} = 1 + \tau \left(\frac{M_c}{M_s} - 1 \right)$$

Values of the settlement reduction ratio, step 3, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	f_d (-)	$f_{d,max}$ (-)	f_d (-)	β_2 (-)	$\beta_{2,max}$ (-)	β_2 (-)
1	1.1	1.1	1.1	1.5	1.1	1.7	1.9	1.7
2	1.1	1.2	1.1	1.5	1.1	1.7	1.9	1.7
3	1.2	1.2	1.1	1.5	1.1	1.7	1.9	1.7
4	1.2	1.3	1.1	1.5	1.1	1.7	1.9	1.7
5	1.3	1.3	1.1	1.5	1.1	1.7	1.9	1.7
6	1.3	1.3	1.1	1.5	1.1	1.7	1.9	1.7
7	1.3	1.4	1.1	1.5	1.1	1.7	1.9	1.7
8	1.4	1.4	1.1	1.5	1.1	1.7	1.9	1.7
9	1.4	1.5	1.1	1.5	1.1	1.7	1.9	1.7
10	1.5	1.5	1.1	1.5	1.1	1.7	1.9	1.7

Settlement distribution per layer

Over the length of the columns

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)	S_a (m)
1	1.1	1.1	0.001	0.000
2	1.1	1.2	0.001	0.000
3	1.2	1.2	0.001	0.000
4	1.2	1.3	0.001	0.000
5	1.3	1.3	0.001	0.000
6	1.3	1.3	0.001	0.000
7	1.3	1.4	0.001	0.000
8	1.4	1.4	0.001	0.000
9	1.4	1.5	0.001	0.000
10	1.5	1.5	0.001	0.000
		TOTAL	**0.007**	**0.004**

Notations

S_{na} *Settlement of soil without soil improvement*

S_a *Settlement of soil with soil improvement*

The total settlement in the soil w/o improvement under an uniform load is: **0.7 cm**

The settlement decrease ratio under an uniform load is: **1.7**

The total settlement of the improved soil under an uniform load is: **0.4 cm**

Below the improved soil layers

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)
11	1.5	3.5	0.003
12	3.5	10.0	0.022
		TOTAL	**0.025**

The settlement below the improved soil layers is: **2.5 cm**

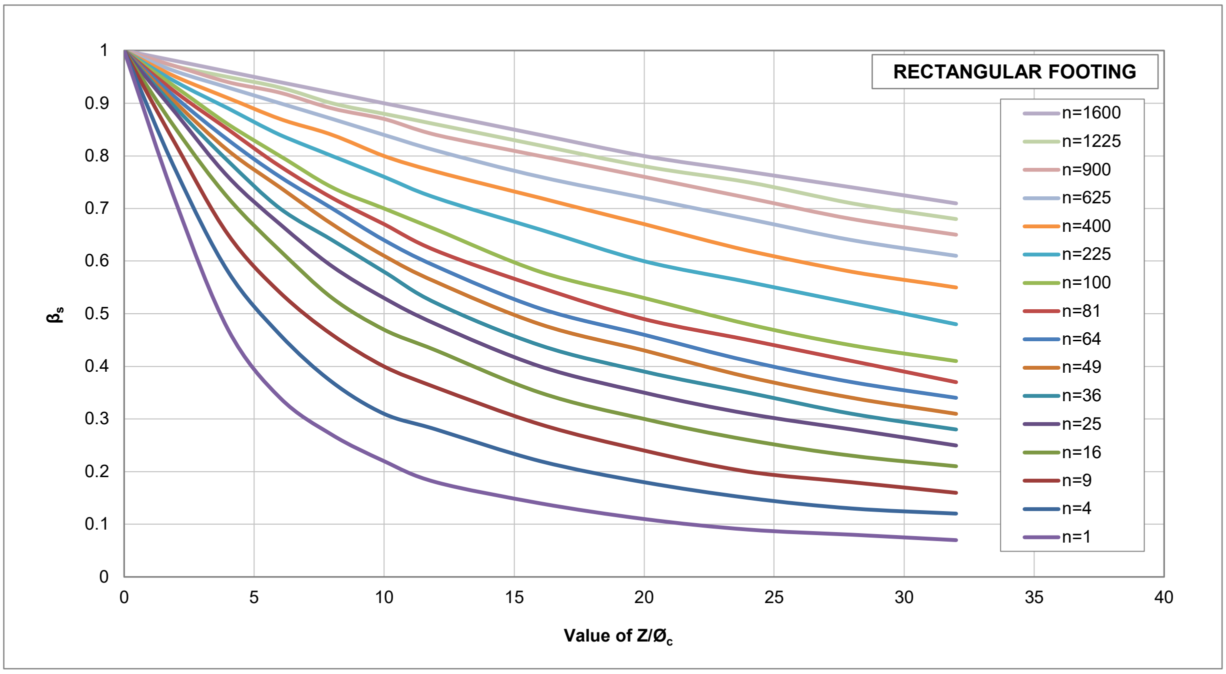
THE TOTAL SETTLEMENT OF THE SOIL UNDER AN UNIFORM LOAD IS **2.9 cm**

LOADING ON THE FOOTING

Settlement distribution

Over the length of the columns

This calculation is made by applying a new settlement reduction factor β_s to the settlement of the soil improved by stone columns.
Priebe has given a diagram of β_s values depending on the depth/diameter ratio $z/Ø_c$ and number of Stone Columns n.



The number of columns below the footing is: 1

The settlement of a layer at a depth Z below the base of the footing is determined as the difference of the settlements calculated between the lower bound Z_{inf} and the upper bound Z_{sup} of the concerned layer, with an average β_s calculated over the thickness of this layer:

$$S_{a,s}(z) = \frac{\Delta q}{M_s \beta_2}\left[(\beta_s)_{inf}.Z_{inf} - (\beta_s)_{sup}.Z_{sup}\right]$$

Layer n°	z_{sup} (m)	z_{inf} (m)	Z_{sup} (m)	Z_{inf} (m)	$Z_{sup}/Ø_c$ (-)	$Z_{inf}/Ø_c$ (-)	$(\beta_s)_{sup}$ (-)	$(\beta_s)_{inf}$ (-)	$S_{a,s}$ (m)
1	1.1	1.1	0.0	0.0	0.00	0.10	1.00	0.99	0.000
2	1.1	1.2	0.0	0.1	0.10	0.20	0.99	0.97	0.000
3	1.2	1.2	0.1	0.1	0.20	0.30	0.97	0.96	0.000
4	1.2	1.3	0.1	0.2	0.30	0.40	0.96	0.94	0.000
5	1.3	1.3	0.2	0.2	0.40	0.50	0.94	0.93	0.000
6	1.3	1.3	0.2	0.2	0.50	0.60	0.93	0.91	0.000
7	1.3	1.4	0.2	0.3	0.60	0.70	0.91	0.90	0.000
8	1.4	1.4	0.3	0.3	0.70	0.80	0.90	0.88	0.000
9	1.4	1.5	0.3	0.4	0.80	0.90	0.88	0.87	0.000
10	1.5	1.5	0.4	0.4	0.90	1.00	0.87	0.86	0.000
								TOTAL	**0.003**

The total settlement of the improved soil under the footing is: 0.3 cm

Notations

Z_{sup}	Depth of the top of the soil layer from the foundation base	$(\beta_s)_{sup}$	Settlement reduction factor at the level of z_{sup}
Z_{inf}	Depth of the bottom of the soil layer from the foundation base	$(\beta_s)_{inf}$	Settlement reduction factor at the level of z_{inf}
$S_{a,s}$	Settlement of soil with soil improvement		

Below the improved soil layers

Layer n°	z_{sup} (m)	z_{inf} (m)	$S_{na,s}$ (m)
11	1.5	3.5	0.001
12	3.5	10.0	0.000
		TOTAL	**0.001**

The settlement below the improved soil layers is: 0.1 cm

THE TOTAL SETTLEMENT OF THE SOIL BELOW THE FOOTING IS 0.5 cm

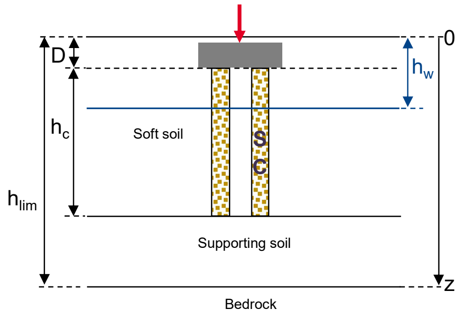
Project name: Poyle pad @150kPa
2.5m x 2.5m pad (B)

Area of the rectangular footing: 2.50 m x 2.50 m — Footing loaded at ΔQ = 937.5 kN

DESIGN AS PER PRIEBE METHOD

Presentation of the model and main calculation results

ΔQ = 937.5 kN



Area of the footing = 6.25 m²

Diameter of the columns = 0.4 m to 0.4 m

Total settlement = 0.9 cm

Maximal stress within the columns = 598.4 kPa

Description of Stone Columns reinforcement

Description of the footing

Type of footing: **Rectangular**

L	2.5 m	Length of the footing	d	1.1 m	Embedment height
B	2.5 m	Width of the footing	$A_{footing}$	6.25 m²	Area of the footing

Number of columns under the footing: 4

Description of the stone columns

A	1.56 m²	Equivalent grid area of the columns	γ_c	20 kN/m³	Unit weight of the gravel
h_c	0.4 m	Length of the columns	φ_c	38 °	Friction angle of the gravel
E_c	50,000 kPa	Young's modulus	Ka_c	0.24	Coefficient of active earth pressure
ν_c	0.33	Poisson's coefficient	K_{0c}	0.38	Coefficient of earth pressure at rest
M_c	75,000 kPa	Oedometric modulus			

Description of natural soil surrounding the columns

h_w 1.5 m *Depth of Ground Water Table*

Priebe considers: $K_{0s} = 1$ *with K_{0s} : coefficient of earth pressure at rest*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	ν_s (-)	γ_s (kN/m³)	M_s (kPa)	$Ø_c$ (m)	τ (%)	p_l^* (kPa)
1	1.1	1.1	6,000	0.33	18	9,000	0.40	8.0%	400
2	1.1	1.2	6,000	0.33	18	9,000	0.40	8.0%	400
3	1.2	1.2	6,000	0.33	18	9,000	0.40	8.0%	400
4	1.2	1.3	6,000	0.33	18	9,000	0.40	8.0%	400
5	1.3	1.3	6,000	0.33	18	9,000	0.40	8.0%	400
6	1.3	1.3	6,000	0.33	18	9,000	0.40	8.0%	400
7	1.3	1.4	6,000	0.33	18	9,000	0.40	8.0%	400
8	1.4	1.4	6,000	0.33	18	9,000	0.40	8.0%	400
9	1.4	1.5	6,000	0.33	18	9,000	0.40	8.0%	400
10	1.5	1.5	6,000	0.33	18	9,000	0.40	8.0%	400

Description of natural soil below the columns

h_{lim} 10.0 m *Limit depth of model*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	ν_s (-)	M_s (kPa)
11	1.5	3.5	60,000	0.33	90,000
12	3.5	10.0	30,000	0.33	45,000

Notations

z_{sup}	Depth of the top of the soil layer	M_s	Oedometric modulus in the layer
z_{inf}	Depth of the bottom of the soil layer	$Ø_c$	Stone Columns' diameter
E_s	Young's modulus in the layer	τ	Replacement ratio
ν_s	Poisson's coefficient	p_l^*	Limit pressure in the layer
γ_s	Unit weight of the soil layer		

Loading description at SLS

ΔQ	938 kN	*Load applied at the footing base*
Δq	150.0 kPa	*Pressure applied at the footing base*

UNIFORM LOADING

Hypothesis: columns are not compressible

Priebe suggests to use the following settlement reduction ratio, corresponding to an incompressible gravel:

$$\beta = 1 + \tau\left(\frac{f(\nu_s,\tau) + \frac{1}{2}}{f(\nu_s,\tau).K_{a_c}} - 1\right)$$

With:

$$f(\nu_s,\tau) = \frac{1-\nu_s^2}{1-\nu_s-2\nu_s^2}.\frac{(1-2\nu_s)(1-\tau)}{1-2\nu_s+\tau}$$

Values of the settlement reduction ratio, first step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	$f_0(\nu_s,\tau)$ (-)	β_0 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.1	1.1	1.48	1.4	109.3	614.8
2	1.1	1.2	1.48	1.4	109.3	614.8
3	1.2	1.2	1.48	1.4	109.3	614.8
4	1.2	1.3	1.48	1.4	109.3	614.8
5	1.3	1.3	1.48	1.4	109.3	614.8
6	1.3	1.3	1.48	1.4	109.3	614.8
7	1.3	1.4	1.48	1.4	109.3	614.8
8	1.4	1.4	1.48	1.4	109.3	614.8
9	1.4	1.5	1.48	1.4	109.3	614.8
10	1.5	1.5	1.48	1.4	109.3	614.8

Stress in soil and columns is assessed using the following formula:

$$\beta_0 = \frac{\Delta q}{\Delta q_s}$$

$$\Delta q = \tau.\Delta q_c + (1-\tau).\Delta q_s$$

Notations

Δq_s	*Additional stress on the soil*
Δq_c	*Additional stress in the column*

Column are made of compressible material

To take into account the fact that gravel is compressible, one should modify the replacement ratio value using the compressibility ratio column / soil.

Values of the settlement reduction ratio, second step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	M_c/M_s (-)	$\Delta(1/\tau)$ (-)	$\tau_{corrected}$ (%)	$f(\nu_s,\tau_{corrected})$ (-)	β_1 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.1	1.1	8.3	0.58	7.7%	1.50	1.4	110.8	598.4
2	1.1	1.2	8.3	0.58	7.7%	1.50	1.4	110.8	598.4
3	1.2	1.2	8.3	0.58	7.7%	1.50	1.4	110.8	598.4
4	1.2	1.3	8.3	0.58	7.7%	1.50	1.4	110.8	598.4
5	1.3	1.3	8.3	0.58	7.7%	1.50	1.4	110.8	598.4
6	1.3	1.3	8.3	0.58	7.7%	1.50	1.4	110.8	598.4
7	1.3	1.4	8.3	0.58	7.7%	1.50	1.4	110.8	598.4
8	1.4	1.4	8.3	0.58	7.7%	1.50	1.4	110.8	598.4
9	1.4	1.5	8.3	0.58	7.7%	1.50	1.4	110.8	598.4
10	1.5	1.5	8.3	0.58	7.7%	1.50	1.4	110.8	598.4

Notations

$\Delta(1/\tau)$	*Increase of 1 / τ*
$\tau_{corrected}$	*Modified value of replacement ratio*

Stress distribution per improved layer

The stress distribution ratio is:

$$n = \frac{\Delta q_C}{\Delta q_S} = \frac{f(\nu_s,\tau_{corrected}) + \frac{1}{2}}{f(\nu_s,\tau_{corrected})\cdot K_{a_c}}$$

Layer n°	z_{sup} (m)	z_{inf} (m)	n (-)	$q_{c,0}$ (kPa)	Δq_c (kPa)	q_c (kPa)	$\Delta q_{c,max}$ (kPa)	Checking against bulging failure	$q_{s,0}$ (kPa)	Δq_s (kPa)	q_s (kPa)
1	1.1	1.1	5.6	20.2	598.4	618.6	800.0	OK	20.2	110.8	130.9
2	1.1	1.2	5.6	21.0	598.4	619.4	800.0	OK	20.9	110.8	131.7
3	1.2	1.2	5.6	21.8	598.4	620.2	800.0	OK	21.6	110.8	132.4
4	1.2	1.3	5.6	22.6	598.4	621.0	800.0	OK	22.3	110.8	133.1
5	1.3	1.3	5.6	23.4	598.4	621.8	800.0	OK	23.0	110.8	133.8
6	1.3	1.3	5.6	24.2	598.4	622.6	800.0	OK	23.8	110.8	134.5
7	1.3	1.4	5.6	25.0	598.4	623.4	800.0	OK	24.5	110.8	135.3
8	1.4	1.4	5.6	25.8	598.4	624.2	800.0	OK	25.2	110.8	136.0
9	1.4	1.5	5.6	26.6	598.4	625.0	800.0	OK	25.9	110.8	136.7
10	1.5	1.5	5.6	27.4	598.4	625.8	800.0	OK	26.6	110.8	137.4

Notations

$q_{c,0}$	*Initial effective vertical stress in the column*	$q_{s,0}$	*Initial effective vertical stress in the soil*
q_c	*Final effective vertical stress in the column*	q_s	*Final effective vertical stress in the soil*
$\Delta q_{c,max}$	*Limit value as per DTU 13-2 (Fs = 2)*		

Depth correction factor

To take into account the additional lateral constraint due the earth pressure at depth, the settlement reduction ratio is multiplied by a coefficient f_d.

$$\beta_2 = f_d . \beta_1$$ *and* $$f_d = \frac{1}{1 + \frac{K_{0_c} - \frac{q_{s,0}}{q_{c,0}}}{K_{0_c}} . \frac{q_{c,0}}{\Delta q_c}}$$ *with* $f_d \geq 1$

The coefficient f_d is limited by following formula:

$$f_d \leq \frac{M_c}{M_s} . \frac{\Delta q_s}{\Delta q_c}$$

The settlement reduction ratio β_2 is limited by:

$$\beta_{2,max} = 1 + \tau \left(\frac{M_c}{M_s} - 1 \right)$$

Values of the settlement reduction ratio, step 3, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	f_d (-)	$f_{d,max}$ (-)	f_d (-)	β_2 (-)	$\beta_{2,max}$ (-)	β_2 (-)
1	1.1	1.1	1.1	1.5	1.1	1.4	1.6	1.4
2	1.1	1.2	1.1	1.5	1.1	1.4	1.6	1.4
3	1.2	1.2	1.1	1.5	1.1	1.4	1.6	1.4
4	1.2	1.3	1.1	1.5	1.1	1.4	1.6	1.4
5	1.3	1.3	1.1	1.5	1.1	1.4	1.6	1.4
6	1.3	1.3	1.1	1.5	1.1	1.4	1.6	1.4
7	1.3	1.4	1.1	1.5	1.1	1.4	1.6	1.4
8	1.4	1.4	1.1	1.5	1.1	1.5	1.6	1.5
9	1.4	1.5	1.1	1.5	1.1	1.5	1.6	1.5
10	1.5	1.5	1.1	1.5	1.1	1.5	1.6	1.5

Settlement distribution per layer

Over the length of the columns

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)	S_a (m)
1	1.1	1.1	0.001	0.000
2	1.1	1.2	0.001	0.000
3	1.2	1.2	0.001	0.000
4	1.2	1.3	0.001	0.000
5	1.3	1.3	0.001	0.000
6	1.3	1.3	0.001	0.000
7	1.3	1.4	0.001	0.000
8	1.4	1.4	0.001	0.000
9	1.4	1.5	0.001	0.000
10	1.5	1.5	0.001	0.000
		TOTAL	**0.007**	**0.005**

Notations

S_{na} Settlement of soil without soil improvement

S_a Settlement of soil with soil improvement

The total settlement in the soil w/o improvement under an uniform load is: **0.7 cm**

The settlement decrease ratio under an uniform load is: **1.4**

The total settlement of the improved soil under an uniform load is: **0.5 cm**

Below the improved soil layers

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)
11	1.5	3.5	0.003
12	3.5	10.0	0.022
		TOTAL	**0.025**

The settlement below the improved soil layers is: **2.5 cm**

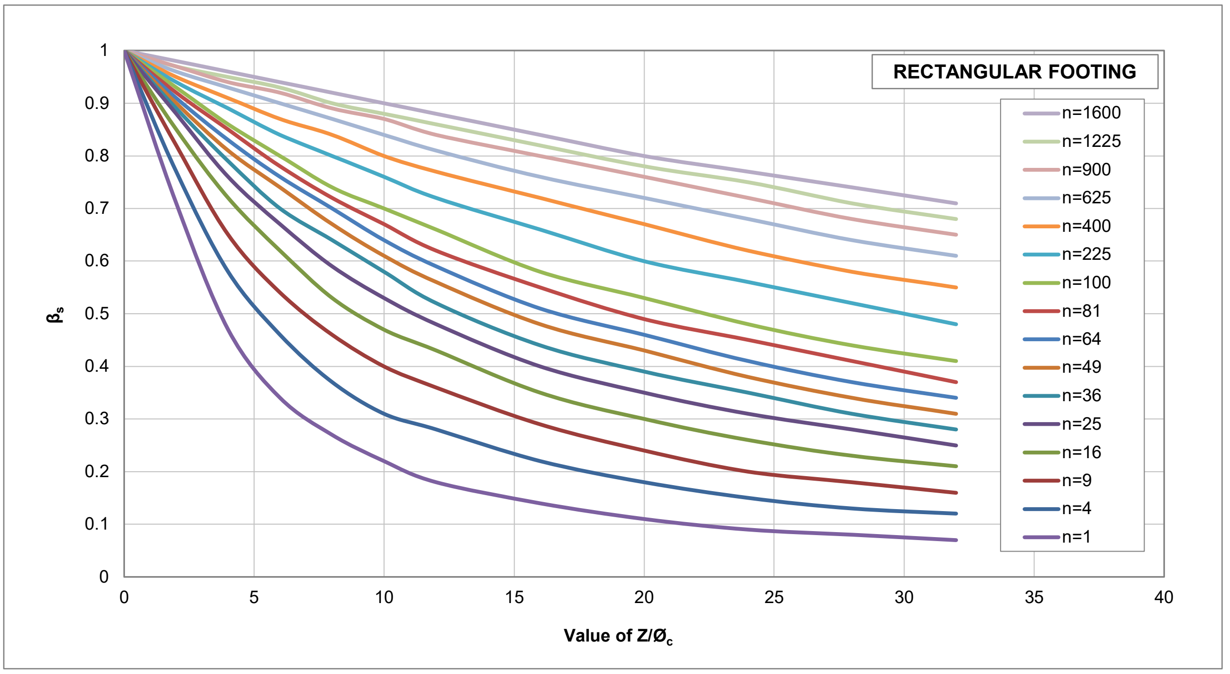
THE TOTAL SETTLEMENT OF THE SOIL UNDER AN UNIFORM LOAD IS **3.0 cm**

LOADING ON THE FOOTING

Settlement distribution

Over the length of the columns

This calculation is made by applying a new settlement reduction factor β_s to the settlement of the soil improved by stone columns.
Priebe has given a diagram of β_s values depending on the depth/diameter ratio $z/Ø_c$ and number of Stone Columns n.



The number of columns below the footing is: 4

The settlement of a layer at a depth Z below the base of the footing is determined as the difference of the settlements calculated between the lower bound Z_{inf} and the upper bound Z_{sup} of the concerned layer, with an average β_s calculated over the thickness of this layer:

$$S_{a,s}(z) = \frac{\Delta q}{M_s \beta_2}\left[(\beta_s)_{inf}.Z_{inf} - (\beta_s)_{sup}.Z_{sup}\right]$$

Layer n°	z sup (m)	z inf (m)	Z sup (m)	Z inf (m)	Z sup /Ø c (-)	Z inf /Ø c (-)	(β s) sup (-)	(β s) inf (-)	S a,s (m)
1	1.1	1.1	0.0	0.0	0.00	0.10	1.00	0.99	0.000
2	1.1	1.2	0.0	0.1	0.10	0.20	0.99	0.98	0.000
3	1.2	1.2	0.1	0.1	0.20	0.30	0.98	0.97	0.000
4	1.2	1.3	0.1	0.2	0.30	0.40	0.97	0.95	0.000
5	1.3	1.3	0.2	0.2	0.40	0.50	0.95	0.94	0.000
6	1.3	1.3	0.2	0.2	0.50	0.60	0.94	0.93	0.000
7	1.3	1.4	0.2	0.3	0.60	0.70	0.93	0.92	0.000
8	1.4	1.4	0.3	0.3	0.70	0.80	0.92	0.91	0.000
9	1.4	1.5	0.3	0.4	0.80	0.90	0.91	0.90	0.000
10	1.5	1.5	0.4	0.4	0.90	1.00	0.90	0.89	0.000
								TOTAL	**0.004**

The total settlement of the improved soil under the footing is: 0.4 cm

Notations

Z_{sup}	*Depth of the top of the soil layer from the foundation base*	$(\beta_s)_{sup}$	*Settlement reduction factor at the level of z_{sup}*
Z_{inf}	*Depth of the bottom of the soil layer from the foundation base*	$(\beta_s)_{inf}$	*Settlement reduction factor at the level of z_{inf}*
$S_{a,s}$	*Settlement of soil with soil improvement*		

Below the improved soil layers

Layer n°	z sup (m)	z inf (m)	S na,s (m)
11	1.5	3.5	0.002
12	3.5	10.0	0.003
		TOTAL	**0.005**

The settlement below the improved soil layers is: 0.5 cm

THE TOTAL SETTLEMENT OF THE SOIL BELOW THE FOOTING IS 0.9 cm

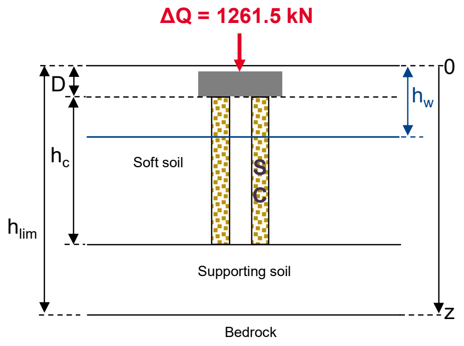
MENARD

Project name: Poyle pad @150kPa
2.9m x 2.9m pad (F)

Area of the rectangular footing: 2.90 m x 2.90 m **Footing loaded at** ΔQ = 1,261.5 kN

DESIGN AS PER PRIEBE METHOD

Presentation of the model and main calculation results



Area of the footing = 8.41 m²

Diameter of the columns = 0.4 m to 0.4 m

Total settlement = 1.0 cm

Maximal stress within the columns = 608.8 kPa

Description of Stone Columns reinforcement

Description of the footing

Type of footing: **Rectangular**

L	2.9 m	*Length of the footing*	d	1.1 m	*Embedment height*
B	2.9 m	*Width of the footing*	$A_{footing}$	8.41 m²	*Area of the footing*

Number of columns under the footing: 5

Description of the stone columns

A	1.68 m²	*Equivalent grid area of the columns*	γ_c	20 kN/m³	*Unit weight of the gravel*
h_c	0.4 m	*Length of the columns*	φ_c	38 °	*Friction angle of the gravel*
E_c	50,000 kPa	*Young's modulus*	Ka_c	0.24	*Coefficient of active earth pressure*
v_c	0.33	*Poisson's coefficient*	K_{0c}	0.38	*Coefficient of earth pressure at rest*
M_c	75,000 kPa	*Oedometric modulus*			

Description of natural soil surrounding the columns

h_w 1.5 m *Depth of Ground Water Table*

Priebe considers: $K_{0s} = 1$ *with K_{0s} : coefficient of earth pressure at rest*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	v_s (-)	γ_s (kN/m³)	M_s (kPa)	$Ø_c$ (m)	τ (%)	p_l* (kPa)
1	1.1	1.1	6,000	0.33	18	9,000	0.40	7.5%	400
2	1.1	1.2	6,000	0.33	18	9,000	0.40	7.5%	400
3	1.2	1.2	6,000	0.33	18	9,000	0.40	7.5%	400
4	1.2	1.3	6,000	0.33	18	9,000	0.40	7.5%	400
5	1.3	1.3	6,000	0.33	18	9,000	0.40	7.5%	400
6	1.3	1.3	6,000	0.33	18	9,000	0.40	7.5%	400
7	1.3	1.4	6,000	0.33	18	9,000	0.40	7.5%	400
8	1.4	1.4	6,000	0.33	18	9,000	0.40	7.5%	400
9	1.4	1.5	6,000	0.33	18	9,000	0.40	7.5%	400
10	1.5	1.5	6,000	0.33	18	9,000	0.40	7.5%	400

Description of natural soil below the columns

h_{lim} 10.0 m *Limit depth of model*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	v_s (-)	M_s (kPa)
11	1.5	3.5	60,000	0.33	90,000
12	3.5	10.0	30,000	0.33	45,000

Notations

z_{sup}	*Depth of the top of the soil layer*	M_s	*Oedometric modulus in the layer*
z_{inf}	*Depth of the bottom of the soil layer*	$Ø_c$	*Stone Columns' diameter*
E_s	*Young's modulus in the layer*	τ	*Replacement ratio*
v_s	*Poisson's coefficient*	p_l*	*Limit pressure in the layer*
γ_s	*Unit weight of the soil layer*		

Loading description at SLS

ΔQ	1,262 kN	*Load applied at the footing base*
Δq	150.0 kPa	*Pressure applied at the footing base*

UNIFORM LOADING

Hypothesis: columns are not compressible

Priebe suggests to use the following settlement reduction ratio, corresponding to an incompressible gravel:

$$\beta = 1 + \tau\left(\frac{f(\nu_s,\tau) + \frac{1}{2}}{f(\nu_s,\tau).K_{a_c}} - 1\right) \quad \text{With:} \quad f(\nu_s,\tau) = \frac{1-\nu_s^2}{1-\nu_s-2\nu_s^2}\cdot\frac{(1-2\nu_s)(1-\tau)}{1-2\nu_s+\tau}$$

Values of the settlement reduction ratio, first step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	$f_0(\nu_s,\tau)$ (-)	β_0 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.1	1.1	1.51	1.3	111.7	624.7
2	1.1	1.2	1.51	1.3	111.7	624.7
3	1.2	1.2	1.51	1.3	111.7	624.7
4	1.2	1.3	1.51	1.3	111.7	624.7
5	1.3	1.3	1.51	1.3	111.7	624.7
6	1.3	1.3	1.51	1.3	111.7	624.7
7	1.3	1.4	1.51	1.3	111.7	624.7
8	1.4	1.4	1.51	1.3	111.7	624.7
9	1.4	1.5	1.51	1.3	111.7	624.7
10	1.5	1.5	1.51	1.3	111.7	624.7

Stress in soil and columns is assessed using the following formula:

$$\beta_0 = \frac{\Delta q}{\Delta q_s}$$

$$\Delta q = \tau.\Delta q_c + (1-\tau).\Delta q_s$$

Notations

Δq_s	*Additional stress on the soil*
Δq_c	*Additional stress in the column*

Column are made of compressible material

To take into account the fact that gravel is compressible, one should modify the replacement ratio value using the compressibility ratio column / soil.

Values of the settlement reduction ratio, second step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	M_c/M_s (-)	Δ(1/τ) (-)	$\tau_{corrected}$ (%)	$f(\nu_s,\tau_{corrected})$ (-)	β_1 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.1	1.1	8.3	0.58	7.2%	1.53	1.3	113.0	608.8
2	1.1	1.2	8.3	0.58	7.2%	1.53	1.3	113.0	608.8
3	1.2	1.2	8.3	0.58	7.2%	1.53	1.3	113.0	608.8
4	1.2	1.3	8.3	0.58	7.2%	1.53	1.3	113.0	608.8
5	1.3	1.3	8.3	0.58	7.2%	1.53	1.3	113.0	608.8
6	1.3	1.3	8.3	0.58	7.2%	1.53	1.3	113.0	608.8
7	1.3	1.4	8.3	0.58	7.2%	1.53	1.3	113.0	608.8
8	1.4	1.4	8.3	0.58	7.2%	1.53	1.3	113.0	608.8
9	1.4	1.5	8.3	0.58	7.2%	1.53	1.3	113.0	608.8
10	1.5	1.5	8.3	0.58	7.2%	1.53	1.3	113.0	608.8

Notations

Δ(1/τ)	*Increase of 1 / τ*
$\tau_{corrected}$	*Modified value of replacement ratio*

Stress distribution per improved layer

The stress distribution ratio is:

$$n = \frac{\Delta q_C}{\Delta q_S} = \frac{f(\nu_s,\tau_{corrected}) + \frac{1}{2}}{f(\nu_s,\tau_{corrected})\cdot K_{a_c}}$$

Layer n°	z_{sup} (m)	z_{inf} (m)	n (-)	$q_{c,0}$ (kPa)	Δq_c (kPa)	q_c (kPa)	$\Delta q_{c,max}$ (kPa)	Checking against bulging failure	$q_{s,0}$ (kPa)	Δq_s (kPa)	q_s (kPa)
1	1.1	1.1	5.6	20.2	608.8	629.0	800.0	OK	20.2	113.0	133.1
2	1.1	1.2	5.6	21.0	608.8	629.8	800.0	OK	20.9	113.0	133.8
3	1.2	1.2	5.6	21.8	608.8	630.6	800.0	OK	21.6	113.0	134.6
4	1.2	1.3	5.6	22.6	608.8	631.4	800.0	OK	22.3	113.0	135.3
5	1.3	1.3	5.6	23.4	608.8	632.2	800.0	OK	23.0	113.0	136.0
6	1.3	1.3	5.6	24.2	608.8	633.0	800.0	OK	23.8	113.0	136.7
7	1.3	1.4	5.6	25.0	608.8	633.8	800.0	OK	24.5	113.0	137.4
8	1.4	1.4	5.6	25.8	608.8	634.6	800.0	OK	25.2	113.0	138.2
9	1.4	1.5	5.6	26.6	608.8	635.4	800.0	OK	25.9	113.0	138.9
10	1.5	1.5	5.6	27.4	608.8	636.2	800.0	OK	26.6	113.0	139.6

Notations

$q_{c,0}$	*Initial effective vertical stress in the column*	$q_{s,0}$	*Initial effective vertical stress in the soil*
q_c	*Final effective vertical stress in the column*	q_s	*Final effective vertical stress in the soil*
$\Delta q_{c,max}$	*Limit value as per DTU 13-2 (Fs = 2)*		

Depth correction factor

To take into account the additional lateral constraint due the earth pressure at depth, the settlement reduction ratio is multiplied by a coefficient f_d.

$$\beta_2 = f_d . \beta_1 \quad \text{and} \quad f_d = \frac{1}{1 + \frac{K_{0_c} - \frac{q_{s,0}}{q_{c,0}}}{K_{0_c}} \cdot \frac{q_{c,0}}{\Delta q_c}} \quad \text{with} \quad f_d \geq 1$$

The coefficient f_d is limited by following formula:

$$f_d \leq \frac{M_c}{M_s} \cdot \frac{\Delta q_s}{\Delta q_c}$$

The settlement reduction ratio β_2 is limited by:

$$\beta_{2,max} = 1 + \tau\left(\frac{M_c}{M_s} - 1\right)$$

Values of the settlement reduction ratio, step 3, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	f_d (-)	$f_{d,max}$ (-)	f_d (-)	β_2 (-)	$\beta_{2,max}$ (-)	β_2 (-)
1	1.1	1.1	1.1	1.5	1.1	1.4	1.5	1.4
2	1.1	1.2	1.1	1.5	1.1	1.4	1.5	1.4
3	1.2	1.2	1.1	1.5	1.1	1.4	1.5	1.4
4	1.2	1.3	1.1	1.5	1.1	1.4	1.5	1.4
5	1.3	1.3	1.1	1.5	1.1	1.4	1.5	1.4
6	1.3	1.3	1.1	1.5	1.1	1.4	1.5	1.4
7	1.3	1.4	1.1	1.5	1.1	1.4	1.5	1.4
8	1.4	1.4	1.1	1.5	1.1	1.4	1.5	1.4
9	1.4	1.5	1.1	1.5	1.1	1.4	1.5	1.4
10	1.5	1.5	1.1	1.5	1.1	1.4	1.5	1.4

Settlement distribution per layer

Over the length of the columns

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)	S_a (m)
1	1.1	1.1	0.001	0.000
2	1.1	1.2	0.001	0.000
3	1.2	1.2	0.001	0.000
4	1.2	1.3	0.001	0.000
5	1.3	1.3	0.001	0.000
6	1.3	1.3	0.001	0.000
7	1.3	1.4	0.001	0.000
8	1.4	1.4	0.001	0.000
9	1.4	1.5	0.001	0.000
10	1.5	1.5	0.001	0.000
		TOTAL	**0.007**	**0.005**

Notations

S_{na} Settlement of soil without soil improvement

S_a Settlement of soil with soil improvement

The total settlement in the soil w/o improvement under an uniform load is: **0.7 cm**

The settlement decrease ratio under an uniform load is: **1.4**

The total settlement of the improved soil under an uniform load is: **0.5 cm**

Below the improved soil layers

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)
11	1.5	3.5	0.003
12	3.5	10.0	0.022
		TOTAL	**0.025**

The settlement below the improved soil layers is: **2.5 cm**

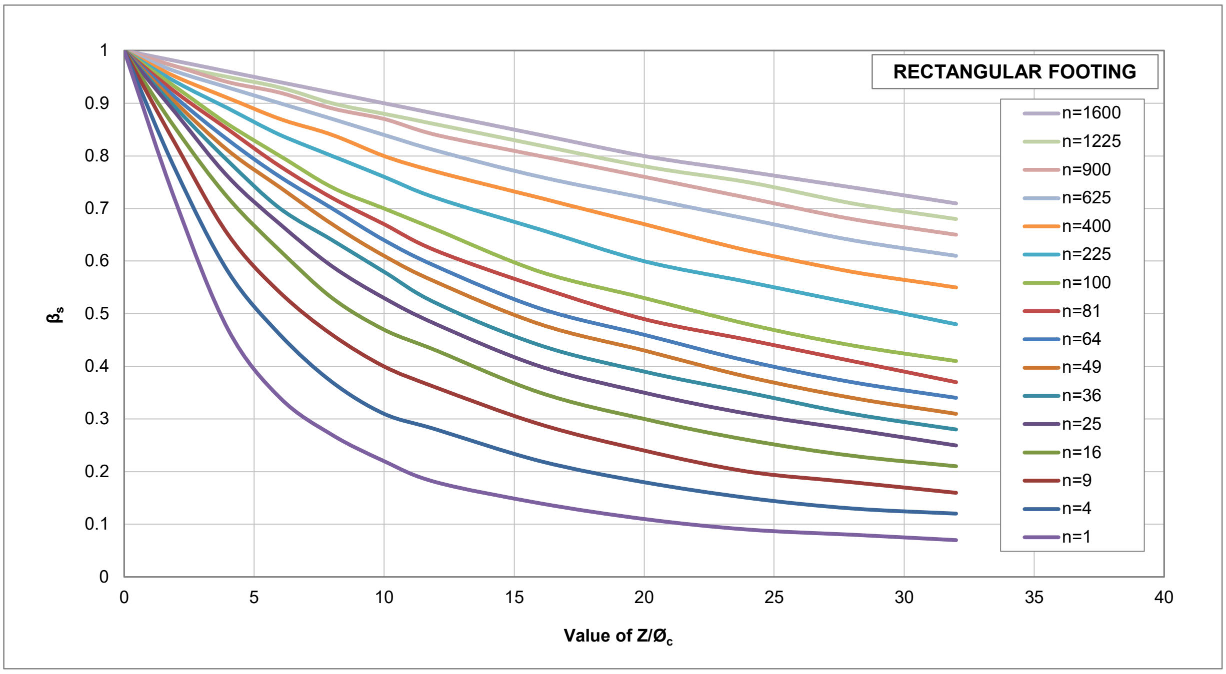
THE TOTAL SETTLEMENT OF THE SOIL UNDER AN UNIFORM LOAD IS **3.0 cm**

LOADING ON THE FOOTING

Settlement distribution

Over the length of the columns

This calculation is made by applying a new settlement reduction factor β_s to the settlement of the soil improved by stone columns.
Priebe has given a diagram of β_s values depending on the depth/diameter ratio $z/Ø_c$ and number of Stone Columns n.



The number of columns below the footing is: 5

The settlement of a layer at a depth Z below the base of the footing is determined as the difference of the settlements calculated between the lower bound Z_{inf} and the upper bound Z_{sup} of the concerned layer, with an average β_s calculated over the thickness of this layer:

$$S_{a,s}(z) = \frac{\Delta q}{M_s \beta_2}\left[(\beta_s)_{inf}.Z_{inf} - (\beta_s)_{sup}.Z_{sup}\right]$$

Layer n°	z sup (m)	z inf (m)	Z sup (m)	Z inf (m)	Z sup /Ø c (-)	Z inf /Ø c (-)	(β s) sup (-)	(β s) inf (-)	S a,s (m)
1	1.1	1.1	0.0	0.0	0.00	0.10	1.00	0.99	0.000
2	1.1	1.2	0.0	0.1	0.10	0.20	0.99	0.98	0.000
3	1.2	1.2	0.1	0.1	0.20	0.30	0.98	0.97	0.000
4	1.2	1.3	0.1	0.2	0.30	0.40	0.97	0.96	0.000
5	1.3	1.3	0.2	0.2	0.40	0.50	0.96	0.95	0.000
6	1.3	1.3	0.2	0.2	0.50	0.60	0.95	0.93	0.000
7	1.3	1.4	0.2	0.3	0.60	0.70	0.93	0.92	0.000
8	1.4	1.4	0.3	0.3	0.70	0.80	0.92	0.91	0.000
9	1.4	1.5	0.3	0.4	0.80	0.90	0.91	0.90	0.000
10	1.5	1.5	0.4	0.4	0.90	1.00	0.90	0.89	0.000
								TOTAL	0.004

The total settlement of the improved soil under the footing is: 0.4 cm

Notations

Z_{sup}	Depth of the top of the soil layer from the foundation base	$(\beta_s)_{sup}$	Settlement reduction factor at the level of z_{sup}
Z_{inf}	Depth of the bottom of the soil layer from the foundation base	$(\beta_s)_{inf}$	Settlement reduction factor at the level of z_{inf}
$S_{a,s}$	Settlement of soil with soil improvement		

Below the improved soil layers

Layer n°	z sup (m)	z inf (m)	S na,s (m)
11	1.5	3.5	0.002
12	3.5	10.0	0.003
		TOTAL	0.006

The settlement below the improved soil layers is: 0.6 cm

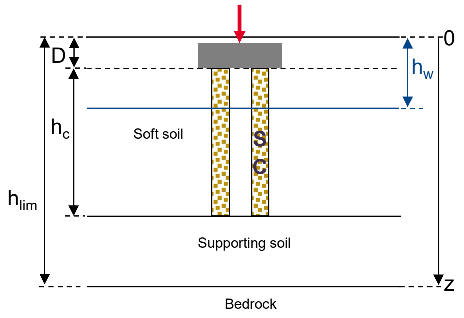
THE TOTAL SETTLEMENT OF THE SOIL BELOW THE FOOTING IS 1.0 cm

Project name: Poyle pad @150kPa
2.9m x 4.5m pad (M)

Area of the rectangular footing: 2.90 m x 4.50 m — Footing loaded at ΔQ = 1,957.5 kN

DESIGN AS PER PRIEBE METHOD

Presentation of the model and main calculation results



Area of the footing = 13.05 m²

Diameter of the columns = 0.4 m to 0.4 m

Total settlement = 1.2 cm

Maximal stress within the columns = 622.8 kPa

Description of Stone Columns reinforcement

Description of the footing

Type of footing: **Rectangular**

L	2.9 m	*Length of the footing*	d	1.2 m	*Embedment height*
B	4.5 m	*Width of the footing*	$A_{footing}$	13.05 m²	*Area of the footing*

Number of columns under the footing: 7

Description of the stone columns

A	1.86 m²	*Equivalent grid area of the columns*	γ_c	20 kN/m³	*Unit weight of the gravel*
h_c	0.4 m	*Length of the columns*	φ_c	38 °	*Friction angle of the gravel*
E_c	50,000 kPa	*Young's modulus*	Ka_c	0.24	*Coefficient of active earth pressure*
ν_c	0.33	*Poisson's coefficient*	K_{0c}	0.38	*Coefficient of earth pressure at rest*
M_c	75,000 kPa	*Oedometric modulus*			

Description of natural soil surrounding the columns

h_w 1.5 m *Depth of Ground Water Table*

Priebe considers: $K_{0s} = 1$ *with K_{0s} : coefficient of earth pressure at rest*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	ν_s (-)	γ_s (kN/m³)	M_s (kPa)	$Ø_c$ (m)	τ (%)	p_l* (kPa)
1	1.2	1.2	6,000	0.33	18	9,000	0.40	6.7%	400
2	1.2	1.3	6,000	0.33	18	9,000	0.40	6.7%	400
3	1.3	1.3	6,000	0.33	18	9,000	0.40	6.7%	400
4	1.3	1.4	6,000	0.33	18	9,000	0.40	6.7%	400
5	1.4	1.4	6,000	0.33	18	9,000	0.40	6.7%	400
6	1.4	1.4	6,000	0.33	18	9,000	0.40	6.7%	400
7	1.4	1.5	6,000	0.33	18	9,000	0.40	6.7%	400
8	1.5	1.5	6,000	0.33	18	9,000	0.40	6.7%	400
9	1.5	1.6	6,000	0.33	18	9,000	0.40	6.7%	400
10	1.6	1.6	6,000	0.33	18	9,000	0.40	6.7%	400

Description of natural soil below the columns

h_{lim} 10.0 m *Limit depth of model*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	ν_s (-)	M_s (kPa)
11	1.6	3.5	60,000	0.33	90,000
12	3.5	10.0	30,000	0.33	45,000

Notations

z_{sup}	*Depth of the top of the soil layer*	M_s	*Oedometric modulus in the layer*
z_{inf}	*Depth of the bottom of the soil layer*	$Ø_c$	*Stone Columns' diameter*
E_s	*Young's modulus in the layer*	τ	*Replacement ratio*
ν_s	*Poisson's coefficient*	p_l*	*Limit pressure in the layer*
γ_s	*Unit weight of the soil layer*		

Loading description at SLS

ΔQ	1,958 kN	*Load applied at the footing base*
Δq	150.0 kPa	*Pressure applied at the footing base*

UNIFORM LOADING

Hypothesis: columns are not compressible

Priebe suggests to use the following settlement reduction ratio, corresponding to an incompressible gravel:

$$\beta = 1 + \tau\left(\frac{f(\nu_s,\tau) + \frac{1}{2}}{f(\nu_s,\tau).K_{a_c}} - 1\right)$$

With:

$$f(\nu_s,\tau) = \frac{1-\nu_s^2}{1-\nu_s-2\nu_s^2}.\frac{(1-2\nu_s)(1-\tau)}{1-2\nu_s+\tau}$$

Values of the settlement reduction ratio, first step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	$f_0(\nu_s,\tau)$ (-)	β_0 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.2	1.2	1.55	1.3	114.7	637.8
2	1.2	1.3	1.55	1.3	114.7	637.8
3	1.3	1.3	1.55	1.3	114.7	637.8
4	1.3	1.4	1.55	1.3	114.7	637.8
5	1.4	1.4	1.55	1.3	114.7	637.8
6	1.4	1.4	1.55	1.3	114.7	637.8
7	1.4	1.5	1.55	1.3	114.7	637.8
8	1.5	1.5	1.55	1.3	114.7	637.8
9	1.5	1.6	1.55	1.3	114.7	637.8
10	1.6	1.6	1.55	1.3	114.7	637.8

Stress in soil and columns is assessed using the following formula:

$$\beta_0 = \frac{\Delta q}{\Delta q_s}$$

$$\Delta q = \tau.\Delta q_c + (1-\tau).\Delta q_s$$

Notations

Δq_s	*Additional stress on the soil*
Δq_c	*Additional stress in the column*

Column are made of compressible material

To take into account the fact that gravel is compressible, one should modify the replacement ratio value using the compressibility ratio column / soil.

Values of the settlement reduction ratio, second step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	M_c/M_s (-)	Δ(1/τ) (-)	$\tau_{corrected}$ (%)	$f(\nu_s,\tau_{corrected})$ (-)	β_1 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.2	1.2	8.3	0.58	6.5%	1.57	1.3	115.8	622.8
2	1.2	1.3	8.3	0.58	6.5%	1.57	1.3	115.8	622.8
3	1.3	1.3	8.3	0.58	6.5%	1.57	1.3	115.8	622.8
4	1.3	1.4	8.3	0.58	6.5%	1.57	1.3	115.8	622.8
5	1.4	1.4	8.3	0.58	6.5%	1.57	1.3	115.8	622.8
6	1.4	1.4	8.3	0.58	6.5%	1.57	1.3	115.8	622.8
7	1.4	1.5	8.3	0.58	6.5%	1.57	1.3	115.8	622.8
8	1.5	1.5	8.3	0.58	6.5%	1.57	1.3	115.8	622.8
9	1.5	1.6	8.3	0.58	6.5%	1.57	1.3	115.8	622.8
10	1.6	1.6	8.3	0.58	6.5%	1.57	1.3	115.8	622.8

Notations

Δ(1/τ)	*Increase of 1 / τ*
$\tau_{corrected}$	*Modified value of replacement ratio*

Stress distribution per improved layer

The stress distribution ratio is:

$$n = \frac{\Delta q_C}{\Delta q_S} = \frac{f(\nu_s,\tau_{corrected}) + \frac{1}{2}}{f(\nu_s,\tau_{corrected}) \cdot K_{a_c}}$$

Layer n°	z_{sup} (m)	z_{inf} (m)	n (-)	$q_{c,0}$ (kPa)	Δq_c (kPa)	q_c (kPa)	$\Delta q_{c,max}$ (kPa)	Checking against bulging failure	$q_{s,0}$ (kPa)	Δq_s (kPa)	q_s (kPa)
1	1.2	1.2	5.5	22.0	622.8	644.8	800.0	OK	22.0	115.8	137.8
2	1.2	1.3	5.5	22.8	622.8	645.6	800.0	OK	22.7	115.8	138.5
3	1.3	1.3	5.5	23.6	622.8	646.4	800.0	OK	23.4	115.8	139.2
4	1.3	1.4	5.5	24.4	622.8	647.2	800.0	OK	24.1	115.8	139.9
5	1.4	1.4	5.5	25.2	622.8	648.0	800.0	OK	24.8	115.8	140.7
6	1.4	1.4	5.5	26.0	622.8	648.8	800.0	OK	25.6	115.8	141.4
7	1.4	1.5	5.5	26.8	622.8	649.6	800.0	OK	26.3	115.8	142.1
8	1.5	1.5	5.5	27.5	622.8	650.3	800.0	OK	26.9	115.8	142.7
9	1.5	1.6	5.5	28.0	622.8	650.8	800.0	OK	27.3	115.8	143.1
10	1.6	1.6	5.5	28.4	622.8	651.2	800.0	OK	27.6	115.8	143.5

Notations

$q_{c,0}$	*Initial effective vertical stress in the column*	$q_{s,0}$	*Initial effective vertical stress in the soil*
q_c	*Final effective vertical stress in the column*	q_s	*Final effective vertical stress in the soil*
$\Delta q_{c,max}$	*Limit value as per DTU 13-2 (Fs = 2)*		

Depth correction factor

To take into account the additional lateral constraint due the earth pressure at depth, the settlement reduction ratio is multiplied by a coefficient f_d.

$$\beta_2 = f_d . \beta_1 \quad \text{and} \quad f_d = \frac{1}{1 + \frac{K_{0_c} - \frac{q_{s,0}}{q_{c,0}}}{K_{0_c}} . \frac{q_{c,0}}{\Delta q_c}} \quad \text{with} \quad f_d \geq 1$$

The coefficient f_d is limited by following formula:

$$f_d \leq \frac{M_c}{M_s} . \frac{\Delta q_s}{\Delta q_c}$$

The settlement reduction ratio β_2 is limited by:

$$\beta_{2,max} = 1 + \tau \left(\frac{M_c}{M_s} - 1 \right)$$

Values of the settlement reduction ratio, step 3, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	f_d (-)	$f_{d,max}$ (-)	f_d (-)	β_2 (-)	$\beta_{2,max}$ (-)	β_2 (-)
1	1.2	1.2	1.1	1.5	1.1	1.4	1.5	1.4
2	1.2	1.3	1.1	1.5	1.1	1.4	1.5	1.4
3	1.3	1.3	1.1	1.5	1.1	1.4	1.5	1.4
4	1.3	1.4	1.1	1.5	1.1	1.4	1.5	1.4
5	1.4	1.4	1.1	1.5	1.1	1.4	1.5	1.4
6	1.4	1.4	1.1	1.5	1.1	1.4	1.5	1.4
7	1.4	1.5	1.1	1.5	1.1	1.4	1.5	1.4
8	1.5	1.5	1.1	1.5	1.1	1.4	1.5	1.4
9	1.5	1.6	1.1	1.5	1.1	1.4	1.5	1.4
10	1.6	1.6	1.1	1.5	1.1	1.4	1.5	1.4

Settlement distribution per layer

Over the length of the columns

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)	S_a (m)
1	1.2	1.2	0.001	0.000
2	1.2	1.3	0.001	0.000
3	1.3	1.3	0.001	0.000
4	1.3	1.4	0.001	0.000
5	1.4	1.4	0.001	0.000
6	1.4	1.4	0.001	0.000
7	1.4	1.5	0.001	0.000
8	1.5	1.5	0.001	0.000
9	1.5	1.6	0.001	0.000
10	1.6	1.6	0.001	0.000
		TOTAL	**0.007**	**0.005**

Notations

- S_{na} — *Settlement of soil without soil improvement*
- S_a — *Settlement of soil with soil improvement*

The total settlement in the soil w/o improvement under an uniform load is: **0.7 cm**

The settlement decrease ratio under an uniform load is: **1.4**

The total settlement of the improved soil under an uniform load is: **0.5 cm**

Below the improved soil layers

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)
11	1.6	3.5	0.003
12	3.5	10.0	0.022
		TOTAL	**0.025**

The settlement below the improved soil layers is: **2.5 cm**

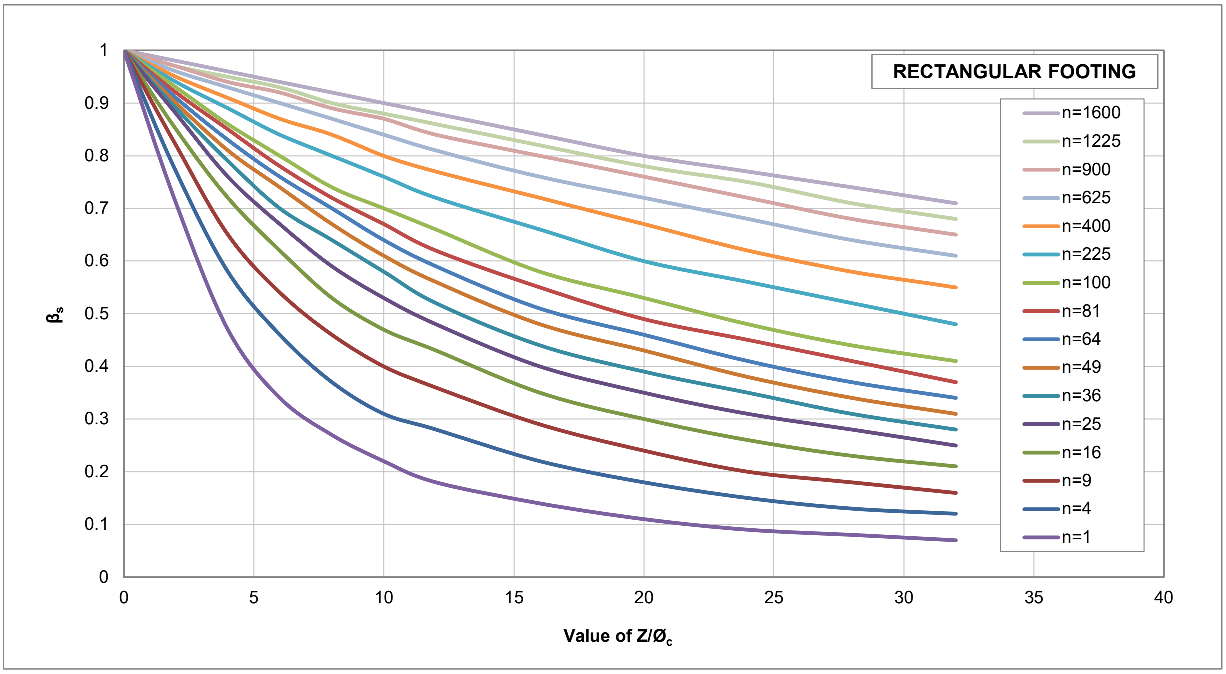
THE TOTAL SETTLEMENT OF THE SOIL UNDER AN UNIFORM LOAD IS **3.0 cm**

LOADING ON THE FOOTING

Settlement distribution

Over the length of the columns

This calculation is made by applying a new settlement reduction factor β_s to the settlement of the soil improved by stone columns.
Priebe has given a diagram of β_s values depending on the depth/diameter ratio $z/Ø_c$ and number of Stone Columns n.



The number of columns below the footing is: 7

The settlement of a layer at a depth Z below the base of the footing is determined as the difference of the settlements calculated between the lower bound Z_{inf} and the upper bound Z_{sup} of the concerned layer, with an average β_s calculated over the thickness of this layer:

$$S_{a,s}(z) = \frac{\Delta q}{M_s \beta_2}\left[(\beta_s)_{inf} . Z_{inf} - (\beta_s)_{sup} . Z_{sup}\right]$$

Layer n°	z sup (m)	z inf (m)	Z sup (m)	Z inf (m)	Z sup/Ø c (-)	Z inf/Ø c (-)	(β s) sup (-)	(β s) inf (-)	S a,s (m)
1	1.2	1.2	0.0	0.0	0.00	0.10	1.00	0.99	0.000
2	1.2	1.3	0.0	0.1	0.10	0.20	0.99	0.98	0.000
3	1.3	1.3	0.1	0.1	0.20	0.30	0.98	0.97	0.000
4	1.3	1.4	0.1	0.2	0.30	0.40	0.97	0.96	0.000
5	1.4	1.4	0.2	0.2	0.40	0.50	0.96	0.95	0.000
6	1.4	1.4	0.2	0.2	0.50	0.60	0.95	0.94	0.000
7	1.4	1.5	0.2	0.3	0.60	0.70	0.94	0.93	0.000
8	1.5	1.5	0.3	0.3	0.70	0.80	0.93	0.92	0.000
9	1.5	1.6	0.3	0.4	0.80	0.90	0.92	0.91	0.000
10	1.6	1.6	0.4	0.4	0.90	1.00	0.91	0.90	0.000
								TOTAL	**0.004**

The total settlement of the improved soil under the footing is: 0.4 cm

Notations

Z_{sup}	*Depth of the top of the soil layer from the foundation base*	$(\beta_s)_{sup}$	*Settlement reduction factor at the level of z_{sup}*
Z_{inf}	*Depth of the bottom of the soil layer from the foundation base*	$(\beta_s)_{inf}$	*Settlement reduction factor at the level of z_{inf}*
$S_{a,s}$	*Settlement of soil with soil improvement*		

Below the improved soil layers

Layer n°	z sup (m)	z inf (m)	S na,s (m)
11	1.6	3.5	0.003
12	3.5	10.0	0.005
		TOTAL	**0.007**

The settlement below the improved soil layers is: 0.7 cm

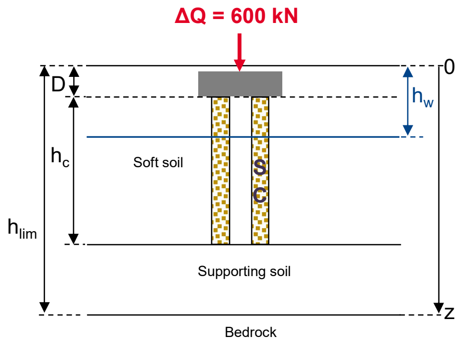
THE TOTAL SETTLEMENT OF THE SOIL BELOW THE FOOTING IS 1.2 cm

Project name: Poyle pad @150kPa
2m x 2m pad

Area of the rectangular footing: 2.00 m x 2.00 m **Footing loaded at** ΔQ = 600.0 kN

DESIGN AS PER PRIEBE METHOD

Presentation of the model and main calculation results



Area of the footing =	4 m²		
Diameter of the columns =	0.4 m	to	0.4 m
Total settlement =	0.8 cm		
Maximal stress within the columns =	631.8 kPa		

Description of Stone Columns reinforcement

Description of the footing

Type of footing: **Rectangular**

L	2	m	*Length of the footing*	d	1.1	m	*Embedment height*
B	2	m	*Width of the footing*	$A_{footing}$	4	m²	*Area of the footing*

Number of columns under the footing: 2

Description of the stone columns

A	2.00	m²	*Equivalent grid area of the columns*	γ_c	20	kN/m³	*Unit weight of the gravel*
h_c	0.4	m	*Length of the columns*	φ_c	38	°	*Friction angle of the gravel*
E_c	50,000	kPa	*Young's modulus*	Ka_c	0.24		*Coefficient of active earth pressure*
v_c	0.33		*Poisson's coefficient*	K_{0c}	0.38		*Coefficient of earth pressure at rest*
M_c	75,000	kPa	*Oedometric modulus*				

Description of natural soil surrounding the columns

h_w 1.5 m *Depth of Ground Water Table*

Priebe considers: $K_{0s} = 1$ *with K_{0s} : coefficient of earth pressure at rest*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	v_s (-)	γ_s (kN/m³)	M_s (kPa)	$Ø_c$ (m)	τ (%)	p_l* (kPa)
1	1.1	1.1	6,000	0.33	18	9,000	0.40	6.3%	400
2	1.1	1.2	6,000	0.33	18	9,000	0.40	6.3%	400
3	1.2	1.2	6,000	0.33	18	9,000	0.40	6.3%	400
4	1.2	1.3	6,000	0.33	18	9,000	0.40	6.3%	400
5	1.3	1.3	6,000	0.33	18	9,000	0.40	6.3%	400
6	1.3	1.3	6,000	0.33	18	9,000	0.40	6.3%	400
7	1.3	1.4	6,000	0.33	18	9,000	0.40	6.3%	400
8	1.4	1.4	6,000	0.33	18	9,000	0.40	6.3%	400
9	1.4	1.5	6,000	0.33	18	9,000	0.40	6.3%	400
10	1.5	1.5	6,000	0.33	18	9,000	0.40	6.3%	400

Description of natural soil below the columns

h_{lim} 10.0 m *Limit depth of model*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	v_s (-)	M_s (kPa)
11	1.5	3.5	60,000	0.33	90,000
12	3.5	10.0	30,000	0.33	45,000

Notations

z_{sup}	*Depth of the top of the soil layer*	M_s	*Oedometric modulus in the layer*
z_{inf}	*Depth of the bottom of the soil layer*	$Ø_c$	*Stone Columns' diameter*
E_s	*Young's modulus in the layer*	τ	*Replacement ratio*
v_s	*Poisson's coefficient*	p_l*	*Limit pressure in the layer*
γ_s	*Unit weight of the soil layer*		

Loading description at SLS

ΔQ	600	kN	*Load applied at the footing base*
Δq	150.0	kPa	*Pressure applied at the footing base*

UNIFORM LOADING

Hypothesis: columns are not compressible

Priebe suggests to use the following settlement reduction ratio, corresponding to an incompressible gravel:

$$\beta = 1 + \tau\left(\frac{f(\nu_s,\tau) + \frac{1}{2}}{f(\nu_s,\tau).K_{a_c}} - 1\right)$$

With:

$$f(\nu_s,\tau) = \frac{1-\nu_s^2}{1-\nu_s-2\nu_s^2}\cdot\frac{(1-2\nu_s)(1-\tau)}{1-2\nu_s+\tau}$$

Values of the settlement reduction ratio, first step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	$f_0(\nu_s,\tau)$ (-)	β_0 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.1	1.1	1.58	1.3	116.7	646.3
2	1.1	1.2	1.58	1.3	116.7	646.3
3	1.2	1.2	1.58	1.3	116.7	646.3
4	1.2	1.3	1.58	1.3	116.7	646.3
5	1.3	1.3	1.58	1.3	116.7	646.3
6	1.3	1.3	1.58	1.3	116.7	646.3
7	1.3	1.4	1.58	1.3	116.7	646.3
8	1.4	1.4	1.58	1.3	116.7	646.3
9	1.4	1.5	1.58	1.3	116.7	646.3
10	1.5	1.5	1.58	1.3	116.7	646.3

Stress in soil and columns is assessed using the following formula:

$$\beta_0 = \frac{\Delta q}{\Delta q_s}$$

$$\Delta q = \tau.\Delta q_c + (1-\tau).\Delta q_s$$

Notations

Δq_s	*Additional stress on the soil*
Δq_c	*Additional stress in the column*

Column are made of compressible material

To take into account the fact that gravel is compressible, one should modify the replacement ratio value using the compressibility ratio column / soil.

Values of the settlement reduction ratio, second step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	M_c/M_s (-)	$\Delta(1/\tau)$ (-)	$\tau_{corrected}$ (%)	$f(\nu_s,\tau_{corrected})$ (-)	β_1 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.1	1.1	8.3	0.58	6.1%	1.59	1.3	117.7	631.8
2	1.1	1.2	8.3	0.58	6.1%	1.59	1.3	117.7	631.8
3	1.2	1.2	8.3	0.58	6.1%	1.59	1.3	117.7	631.8
4	1.2	1.3	8.3	0.58	6.1%	1.59	1.3	117.7	631.8
5	1.3	1.3	8.3	0.58	6.1%	1.59	1.3	117.7	631.8
6	1.3	1.3	8.3	0.58	6.1%	1.59	1.3	117.7	631.8
7	1.3	1.4	8.3	0.58	6.1%	1.59	1.3	117.7	631.8
8	1.4	1.4	8.3	0.58	6.1%	1.59	1.3	117.7	631.8
9	1.4	1.5	8.3	0.58	6.1%	1.59	1.3	117.7	631.8
10	1.5	1.5	8.3	0.58	6.1%	1.59	1.3	117.7	631.8

Notations

$\Delta(1/\tau)$	*Increase of 1 / τ*
$\tau_{corrected}$	*Modified value of replacement ratio*

Stress distribution per improved layer

The stress distribution ratio is:

$$n = \frac{\Delta q_C}{\Delta q_S} = \frac{f(\nu_s,\tau_{corrected}) + \frac{1}{2}}{f(\nu_s,\tau_{corrected})\cdot K_{a_c}}$$

Layer n°	z_{sup} (m)	z_{inf} (m)	n (-)	$q_{c,0}$ (kPa)	Δq_c (kPa)	q_c (kPa)	$\Delta q_{c,max}$ (kPa)	Checking against bulging failure	$q_{s,0}$ (kPa)	Δq_s (kPa)	q_s (kPa)
1	1.1	1.1	5.5	20.2	631.8	652.0	800.0	OK	20.2	117.7	137.9
2	1.1	1.2	5.5	21.0	631.8	652.8	800.0	OK	20.9	117.7	138.6
3	1.2	1.2	5.5	21.8	631.8	653.6	800.0	OK	21.6	117.7	139.3
4	1.2	1.3	5.5	22.6	631.8	654.4	800.0	OK	22.3	117.7	140.0
5	1.3	1.3	5.5	23.4	631.8	655.2	800.0	OK	23.0	117.7	140.7
6	1.3	1.3	5.5	24.2	631.8	656.0	800.0	OK	23.8	117.7	141.5
7	1.3	1.4	5.5	25.0	631.8	656.8	800.0	OK	24.5	117.7	142.2
8	1.4	1.4	5.5	25.8	631.8	657.6	800.0	OK	25.2	117.7	142.9
9	1.4	1.5	5.5	26.6	631.8	658.4	800.0	OK	25.9	117.7	143.6
10	1.5	1.5	5.5	27.4	631.8	659.2	800.0	OK	26.6	117.7	144.3

Notations

$q_{c,0}$	*Initial effective vertical stress in the column*
q_c	*Final effective vertical stress in the column*
$\Delta q_{c,max}$	*Limit value as per DTU 13-2 (Fs = 2)*
$q_{s,0}$	*Initial effective vertical stress in the soil*
q_s	*Final effective vertical stress in the soil*

Depth correction factor

To take into account the additional lateral constraint due the earth pressure at depth, the settlement reduction ratio is multiplied by a coefficient f_d.

$$\beta_2 = f_d . \beta_1 \quad \text{and} \quad f_d = \frac{1}{1 + \frac{K_{0_c} - \frac{q_{s,0}}{q_{c,0}}}{K_{0_c}} . \frac{q_{c,0}}{\Delta q_c}} \quad \text{with} \quad f_d \geq 1$$

The coefficient f_d is limited by following formula:

$$f_d \leq \frac{M_c}{M_s} . \frac{\Delta q_s}{\Delta q_c}$$

The settlement reduction ratio β_2 is limited by:

$$\beta_{2,max} = 1 + \tau\left(\frac{M_c}{M_s} - 1\right)$$

Values of the settlement reduction ratio, step 3, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	f_d (-)	$f_{d,max}$ (-)	f_d (-)	β_2 (-)	$\beta_{2,max}$ (-)	β_2 (-)
1	1.1	1.1	1.1	1.6	1.1	1.3	1.5	1.3
2	1.1	1.2	1.1	1.6	1.1	1.3	1.5	1.3
3	1.2	1.2	1.1	1.6	1.1	1.3	1.5	1.3
4	1.2	1.3	1.1	1.6	1.1	1.4	1.5	1.4
5	1.3	1.3	1.1	1.6	1.1	1.4	1.5	1.4
6	1.3	1.3	1.1	1.6	1.1	1.4	1.5	1.4
7	1.3	1.4	1.1	1.6	1.1	1.4	1.5	1.4
8	1.4	1.4	1.1	1.6	1.1	1.4	1.5	1.4
9	1.4	1.5	1.1	1.6	1.1	1.4	1.5	1.4
10	1.5	1.5	1.1	1.6	1.1	1.4	1.5	1.4

Settlement distribution per layer

Over the length of the columns

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)	S_a (m)
1	1.1	1.1	0.001	0.000
2	1.1	1.2	0.001	0.000
3	1.2	1.2	0.001	0.000
4	1.2	1.3	0.001	0.000
5	1.3	1.3	0.001	0.000
6	1.3	1.3	0.001	0.000
7	1.3	1.4	0.001	0.000
8	1.4	1.4	0.001	0.000
9	1.4	1.5	0.001	0.000
10	1.5	1.5	0.001	0.000
		TOTAL	**0.007**	**0.005**

Notations

S_{na} *Settlement of soil without soil improvement*

S_a *Settlement of soil with soil improvement*

The total settlement in the soil w/o improvement under an uniform load is: 0.7 cm

The settlement decrease ratio under an uniform load is: 1.4

The total settlement of the improved soil under an uniform load is: 0.5 cm

Below the improved soil layers

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)
11	1.5	3.5	0.003
12	3.5	10.0	0.022
		TOTAL	**0.025**

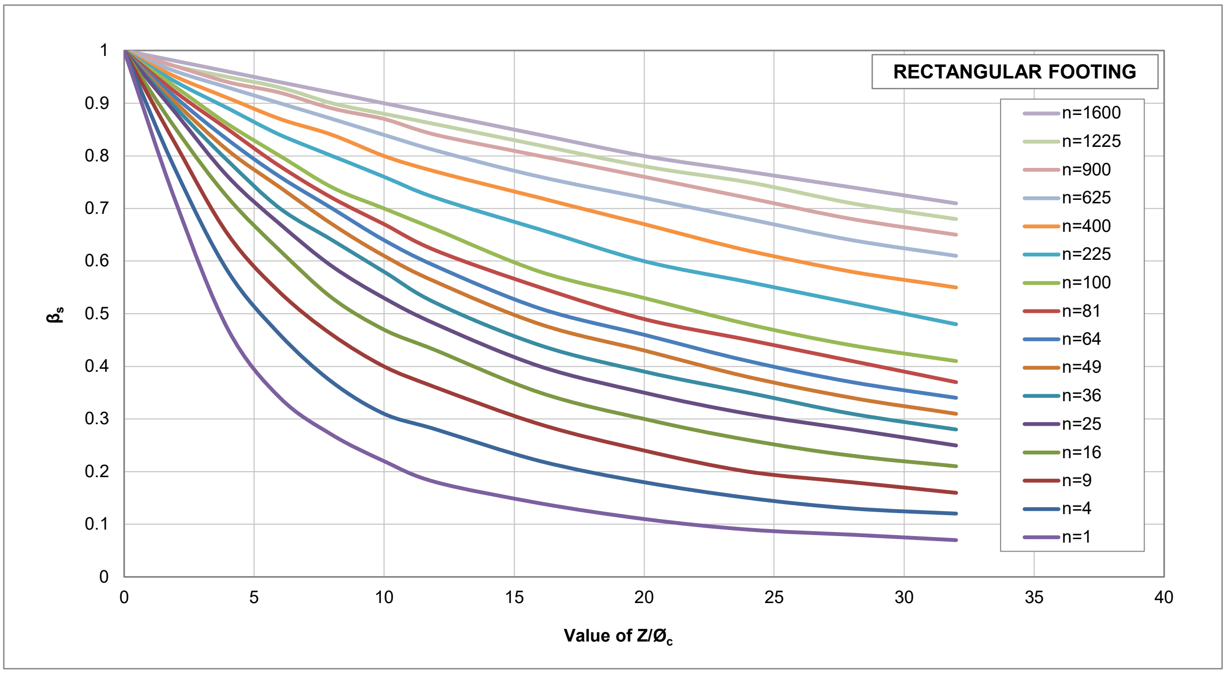
The settlement below the improved soil layers is: 2.5 cm

THE TOTAL SETTLEMENT OF THE SOIL UNDER AN UNIFORM LOAD IS 3.0 cm

Settlement distribution

Over the length of the columns

This calculation is made by applying a new settlement reduction factor β_s to the settlement of the soil improved by stone columns.
Priebe has given a diagram of β_s values depending on the depth/diameter ratio $z/Ø_c$ and number of Stone Columns n.



The number of columns below the footing is: 2

The settlement of a layer at a depth Z below the base of the footing is determined as the difference of the settlements calculated between the lower bound Z_{inf} and the upper bound Z_{sup} of the concerned layer, with an average β_s calculated over the thickness of this layer:

$$S_{a,s}(z) = \frac{\Delta q}{M_s \beta_2}\left[(\beta_s)_{inf}.Z_{inf} - (\beta_s)_{sup}.Z_{sup}\right]$$

Layer n°	z sup (m)	z inf (m)	Z sup (m)	Z inf (m)	Z sup /Ø c (-)	Z inf /Ø c (-)	(β s) sup (-)	(β s) inf (-)	S a,s (m)
1	1.1	1.1	0.0	0.0	0.00	0.10	1.00	0.99	0.000
2	1.1	1.2	0.0	0.1	0.10	0.20	0.99	0.97	0.000
3	1.2	1.2	0.1	0.1	0.20	0.30	0.97	0.96	0.000
4	1.2	1.3	0.1	0.2	0.30	0.40	0.96	0.95	0.000
5	1.3	1.3	0.2	0.2	0.40	0.50	0.95	0.93	0.000
6	1.3	1.3	0.2	0.2	0.50	0.60	0.93	0.92	0.000
7	1.3	1.4	0.2	0.3	0.60	0.70	0.92	0.91	0.000
8	1.4	1.4	0.3	0.3	0.70	0.80	0.91	0.89	0.000
9	1.4	1.5	0.3	0.4	0.80	0.90	0.89	0.88	0.000
10	1.5	1.5	0.4	0.4	0.90	1.00	0.88	0.87	0.000
								TOTAL	0.004

The total settlement of the improved soil under the footing is: 0.4 cm

Notations

Z_{sup}	Depth of the top of the soil layer from the foundation base	$(\beta_s)_{sup}$	Settlement reduction factor at the level of z_{sup}
Z_{inf}	Depth of the bottom of the soil layer from the foundation base	$(\beta_s)_{inf}$	Settlement reduction factor at the level of z_{inf}
$S_{a,s}$	Settlement of soil with soil improvement		

Below the improved soil layers

Layer n°	z sup (m)	z inf (m)	S na,s (m)
11	1.5	3.5	0.002
12	3.5	10.0	0.002
		TOTAL	0.004

The settlement below the improved soil layers is: 0.4 cm

THE TOTAL SETTLEMENT OF THE SOIL BELOW THE FOOTING IS 0.8 cm

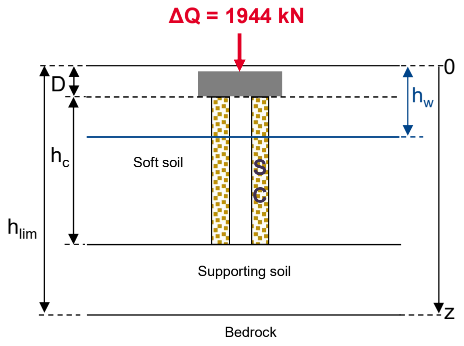
MENARD

Project name: Poyle pad @150kPa
3.6m x 3.6m pad (D)

Area of the rectangular footing: 3.60 m x 3.60 m **Footing loaded at** ΔQ = 1,944.0 kN

DESIGN AS PER PRIEBE METHOD

Presentation of the model and main calculation results



Area of the footing = 12.96 m²

Diameter of the columns = 0.4 m to 0.4 m

Total settlement = 1.2 cm

Maximal stress within the columns = 621.9 kPa

Description of Stone Columns reinforcement

Description of the footing

Type of footing: **Rectangular**

L	3.6 m	*Length of the footing*	d	1.1 m	*Embedment height*
B	3.6 m	*Width of the footing*	$A_{footing}$	12.96 m²	*Area of the footing*

Number of columns under the footing: 7

Description of the stone columns

A	1.85 m²	*Equivalent grid area of the columns*	γ_c	20 kN/m³	*Unit weight of the gravel*
h_c	0.4 m	*Length of the columns*	φ_c	38 °	*Friction angle of the gravel*
E_c	50,000 kPa	*Young's modulus*	Ka_c	0.24	*Coefficient of active earth pressure*
v_c	0.33	*Poisson's coefficient*	K_{0c}	0.38	*Coefficient of earth pressure at rest*
M_c	75,000 kPa	*Oedometric modulus*			

Description of natural soil surrounding the columns

h_w 1.5 m *Depth of Ground Water Table*

Priebe considers: $K_{0s} = 1$ *with K_{0s} : coefficient of earth pressure at rest*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	v_s (-)	γ_s (kN/m³)	M_s (kPa)	$Ø_c$ (m)	τ (%)	p_l* (kPa)
1	1.1	1.1	6,000	0.33	18	9,000	0.40	6.8%	400
2	1.1	1.2	6,000	0.33	18	9,000	0.40	6.8%	400
3	1.2	1.2	6,000	0.33	18	9,000	0.40	6.8%	400
4	1.2	1.3	6,000	0.33	18	9,000	0.40	6.8%	400
5	1.3	1.3	6,000	0.33	18	9,000	0.40	6.8%	400
6	1.3	1.3	6,000	0.33	18	9,000	0.40	6.8%	400
7	1.3	1.4	6,000	0.33	18	9,000	0.40	6.8%	400
8	1.4	1.4	6,000	0.33	18	9,000	0.40	6.8%	400
9	1.4	1.5	6,000	0.33	18	9,000	0.40	6.8%	400
10	1.5	1.5	6,000	0.33	18	9,000	0.40	6.8%	400

Description of natural soil below the columns

h_{lim} 10.0 m *Limit depth of model*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	v_s (-)	M_s (kPa)
11	1.5	3.5	60,000	0.33	90,000
12	3.5	10.0	30,000	0.33	45,000

Notations

z_{sup}	*Depth of the top of the soil layer*	M_s	*Oedometric modulus in the layer*
z_{inf}	*Depth of the bottom of the soil layer*	$Ø_c$	*Stone Columns' diameter*
E_s	*Young's modulus in the layer*	τ	*Replacement ratio*
v_s	*Poisson's coefficient*	p_l*	*Limit pressure in the layer*
γ_s	*Unit weight of the soil layer*		

Loading description at SLS

ΔQ	1,944 kN	*Load applied at the footing base*
Δq	150.0 kPa	*Pressure applied at the footing base*

UNIFORM LOADING

Hypothesis: columns are not compressible

Priebe suggests to use the following settlement reduction ratio, corresponding to an incompressible gravel:

$$\beta = 1 + \tau\left(\frac{f(\nu_s,\tau) + \frac{1}{2}}{f(\nu_s,\tau).K_{a_c}} - 1\right)$$

With:

$$f(\nu_s,\tau) = \frac{1-\nu_s^2}{1-\nu_s-2\nu_s^2}\cdot\frac{(1-2\nu_s)(1-\tau)}{1-2\nu_s+\tau}$$

Values of the settlement reduction ratio, first step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	$f_0(\nu_s,\tau)$ (-)	β_0 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.1	1.1	1.55	1.3	114.5	636.9
2	1.1	1.2	1.55	1.3	114.5	636.9
3	1.2	1.2	1.55	1.3	114.5	636.9
4	1.2	1.3	1.55	1.3	114.5	636.9
5	1.3	1.3	1.55	1.3	114.5	636.9
6	1.3	1.3	1.55	1.3	114.5	636.9
7	1.3	1.4	1.55	1.3	114.5	636.9
8	1.4	1.4	1.55	1.3	114.5	636.9
9	1.4	1.5	1.55	1.3	114.5	636.9
10	1.5	1.5	1.55	1.3	114.5	636.9

Stress in soil and columns is assessed using the following formula:

$$\beta_0 = \frac{\Delta q}{\Delta q_s}$$

$$\Delta q = \tau.\Delta q_c + (1-\tau).\Delta q_s$$

Notations

Δq_s	*Additional stress on the soil*
Δq_c	*Additional stress in the column*

Column are made of compressible material

To take into account the fact that gravel is compressible, one should modify the replacement ratio value using the compressibility ratio column / soil.

Values of the settlement reduction ratio, second step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	M_c/M_s (-)	$\Delta(1/\tau)$ (-)	$\tau_{corrected}$ (%)	$f(\nu_s,\tau_{corrected})$ (-)	β_1 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.1	1.1	8.3	0.58	6.5%	1.56	1.3	115.6	621.9
2	1.1	1.2	8.3	0.58	6.5%	1.56	1.3	115.6	621.9
3	1.2	1.2	8.3	0.58	6.5%	1.56	1.3	115.6	621.9
4	1.2	1.3	8.3	0.58	6.5%	1.56	1.3	115.6	621.9
5	1.3	1.3	8.3	0.58	6.5%	1.56	1.3	115.6	621.9
6	1.3	1.3	8.3	0.58	6.5%	1.56	1.3	115.6	621.9
7	1.3	1.4	8.3	0.58	6.5%	1.56	1.3	115.6	621.9
8	1.4	1.4	8.3	0.58	6.5%	1.56	1.3	115.6	621.9
9	1.4	1.5	8.3	0.58	6.5%	1.56	1.3	115.6	621.9
10	1.5	1.5	8.3	0.58	6.5%	1.56	1.3	115.6	621.9

Notations

$\Delta(1/\tau)$	*Increase of 1 / τ*
$\tau_{corrected}$	*Modified value of replacement ratio*

Stress distribution per improved layer

The stress distribution ratio is:

$$n = \frac{\Delta q_C}{\Delta q_S} = \frac{f(\nu_s,\tau_{corrected}) + \frac{1}{2}}{f(\nu_s,\tau_{corrected})\cdot K_{a_c}}$$

Layer n°	z_{sup} (m)	z_{inf} (m)	n (-)	$q_{c,0}$ (kPa)	Δq_c (kPa)	q_c (kPa)	$\Delta q_{c,max}$ (kPa)	Checking against bulging failure	$q_{s,0}$ (kPa)	Δq_s (kPa)	q_s (kPa)
1	1.1	1.1	5.5	20.2	621.9	642.1	800.0	OK	20.2	115.6	135.8
2	1.1	1.2	5.5	21.0	621.9	642.9	800.0	OK	20.9	115.6	136.5
3	1.2	1.2	5.5	21.8	621.9	643.7	800.0	OK	21.6	115.6	137.2
4	1.2	1.3	5.5	22.6	621.9	644.5	800.0	OK	22.3	115.6	138.0
5	1.3	1.3	5.5	23.4	621.9	645.3	800.0	OK	23.0	115.6	138.7
6	1.3	1.3	5.5	24.2	621.9	646.1	800.0	OK	23.8	115.6	139.4
7	1.3	1.4	5.5	25.0	621.9	646.9	800.0	OK	24.5	115.6	140.1
8	1.4	1.4	5.5	25.8	621.9	647.7	800.0	OK	25.2	115.6	140.8
9	1.4	1.5	5.5	26.6	621.9	648.5	800.0	OK	25.9	115.6	141.6
10	1.5	1.5	5.5	27.4	621.9	649.3	800.0	OK	26.6	115.6	142.3

Notations

$q_{c,0}$	*Initial effective vertical stress in the column*	$q_{s,0}$	*Initial effective vertical stress in the soil*
q_c	*Final effective vertical stress in the column*	q_s	*Final effective vertical stress in the soil*
$\Delta q_{c,max}$	*Limit value as per DTU 13-2 (Fs = 2)*		

Depth correction factor

To take into account the additional lateral constraint due the earth pressure at depth, the settlement reduction ratio is multiplied by a coefficient f_d.

$$\beta_2 = f_d . \beta_1 \quad \text{and} \quad f_d = \frac{1}{1 + \frac{K_{0_c} - \frac{q_{s,0}}{q_{c,0}}}{K_{0_c}} . \frac{q_{c,0}}{\Delta q_c}} \quad \text{with} \quad f_d \geq 1$$

The coefficient f_d is limited by following formula:

$$f_d \leq \frac{M_c}{M_s} . \frac{\Delta q_s}{\Delta q_c}$$

The settlement reduction ratio β_2 is limited by:

$$\beta_{2,max} = 1 + \tau\left(\frac{M_c}{M_s} - 1\right)$$

Values of the settlement reduction ratio, step 3, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	f_d (-)	$f_{d,max}$ (-)	f_d (-)	β_2 (-)	$\beta_{2,max}$ (-)	β_2 (-)
1	1.1	1.1	1.1	1.5	1.1	1.4	1.5	1.4
2	1.1	1.2	1.1	1.5	1.1	1.4	1.5	1.4
3	1.2	1.2	1.1	1.5	1.1	1.4	1.5	1.4
4	1.2	1.3	1.1	1.5	1.1	1.4	1.5	1.4
5	1.3	1.3	1.1	1.5	1.1	1.4	1.5	1.4
6	1.3	1.3	1.1	1.5	1.1	1.4	1.5	1.4
7	1.3	1.4	1.1	1.5	1.1	1.4	1.5	1.4
8	1.4	1.4	1.1	1.5	1.1	1.4	1.5	1.4
9	1.4	1.5	1.1	1.5	1.1	1.4	1.5	1.4
10	1.5	1.5	1.1	1.5	1.1	1.4	1.5	1.4

Settlement distribution per layer

Over the length of the columns

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)	S_a (m)
1	1.1	1.1	0.001	0.000
2	1.1	1.2	0.001	0.000
3	1.2	1.2	0.001	0.000
4	1.2	1.3	0.001	0.000
5	1.3	1.3	0.001	0.000
6	1.3	1.3	0.001	0.000
7	1.3	1.4	0.001	0.000
8	1.4	1.4	0.001	0.000
9	1.4	1.5	0.001	0.000
10	1.5	1.5	0.001	0.000
		TOTAL	**0.007**	**0.005**

Notations

S_{na} Settlement of soil without soil improvement

S_a Settlement of soil with soil improvement

The total settlement in the soil w/o improvement under an uniform load is: 0.7 cm

The settlement decrease ratio under an uniform load is: 1.4

The total settlement of the improved soil under an uniform load is: 0.5 cm

Below the improved soil layers

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)
11	1.5	3.5	0.003
12	3.5	10.0	0.022
		TOTAL	**0.025**

The settlement below the improved soil layers is: 2.5 cm

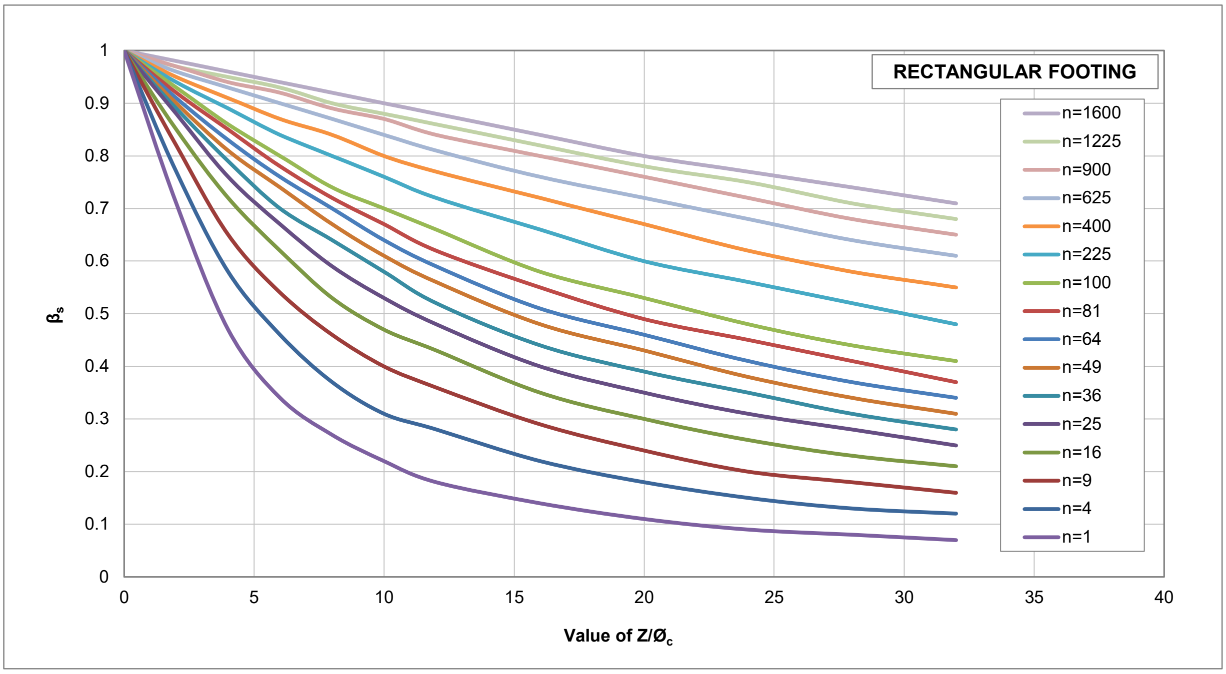
THE TOTAL SETTLEMENT OF THE SOIL UNDER AN UNIFORM LOAD IS 3.0 cm

LOADING ON THE FOOTING

Settlement distribution

Over the length of the columns

This calculation is made by applying a new settlement reduction factor β_s to the settlement of the soil improved by stone columns. Priebe has given a diagram of β_s values depending on the depth/diameter ratio $z/Ø_c$ and number of Stone Columns n.



The number of columns below the footing is: 7

The settlement of a layer at a depth Z below the base of the footing is determined as the difference of the settlements calculated between the lower bound Z_{inf} and the upper bound Z_{sup} of the concerned layer, with an average β_s calculated over the thickness of this layer:

$$S_{a,s}(z) = \frac{\Delta q}{M_s \beta_2}\left[(\beta_s)_{inf}.Z_{inf} - (\beta_s)_{sup}.Z_{sup}\right]$$

Layer n°	z_{sup} (m)	z_{inf} (m)	Z_{sup} (m)	Z_{inf} (m)	$Z_{sup}/Ø_c$ (-)	$Z_{inf}/Ø_c$ (-)	$(\beta_s)_{sup}$ (-)	$(\beta_s)_{inf}$ (-)	$S_{a,s}$ (m)
1	1.1	1.1	0.0	0.0	0.00	0.10	1.00	0.99	0.000
2	1.1	1.2	0.0	0.1	0.10	0.20	0.99	0.98	0.000
3	1.2	1.2	0.1	0.1	0.20	0.30	0.98	0.97	0.000
4	1.2	1.3	0.1	0.2	0.30	0.40	0.97	0.96	0.000
5	1.3	1.3	0.2	0.2	0.40	0.50	0.96	0.95	0.000
6	1.3	1.3	0.2	0.2	0.50	0.60	0.95	0.94	0.000
7	1.3	1.4	0.2	0.3	0.60	0.70	0.94	0.93	0.000
8	1.4	1.4	0.3	0.3	0.70	0.80	0.93	0.92	0.000
9	1.4	1.5	0.3	0.4	0.80	0.90	0.92	0.91	0.000
10	1.5	1.5	0.4	0.4	0.90	1.00	0.91	0.90	0.000
								TOTAL	**0.004**

The total settlement of the improved soil under the footing is: 0.4 cm

Notations

Z_{sup}	*Depth of the top of the soil layer from the foundation base*	$(\beta_s)_{sup}$	*Settlement reduction factor at the level of z_{sup}*
Z_{inf}	*Depth of the bottom of the soil layer from the foundation base*	$(\beta_s)_{inf}$	*Settlement reduction factor at the level of z_{inf}*
$S_{a,s}$	*Settlement of soil with soil improvement*		

Below the improved soil layers

Layer n°	z_{sup} (m)	z_{inf} (m)	$S_{na,s}$ (m)
11	1.5	3.5	0.003
12	3.5	10.0	0.005
		TOTAL	**0.007**

The settlement below the improved soil layers is: 0.7 cm

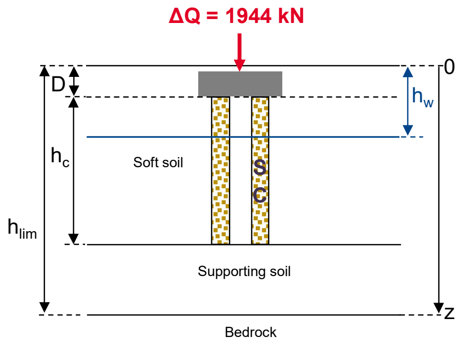
THE TOTAL SETTLEMENT OF THE SOIL BELOW THE FOOTING IS 1.2 cm

Project name: Poyle pad @150kPa
3.6m x 3.6m pad (H)

Area of the rectangular footing: 3.60 m x 3.60 m   Footing loaded at   ΔQ = 1,944.0 kN

DESIGN AS PER PRIEBE METHOD

Presentation of the model and main calculation results



Area of the footing = 12.96 m²

Diameter of the columns = 0.4 m to 0.4 m

Total settlement = 1.1 cm

Maximal stress within the columns = 621.9 kPa

Description of Stone Columns reinforcement

Description of the footing

Type of footing: **Rectangular**

L	3.6 m	*Length of the footing*	d	1.2 m	*Embedment height*
B	3.6 m	*Width of the footing*	$A_{footing}$	12.96 m²	*Area of the footing*

Number of columns under the footing: 7

Description of the stone columns

A	1.85 m²	*Equivalent grid area of the columns*	γ_c	20 kN/m^3	*Unit weight of the gravel*
h_c	0.3 m	*Length of the columns*	φ_c	38 °	*Friction angle of the gravel*
E_c	50,000 kPa	*Young's modulus*	Ka_c	0.24	*Coefficient of active earth pressure*
ν_c	0.33	*Poisson's coefficient*	K_{0c}	0.38	*Coefficient of earth pressure at rest*
M_c	75,000 kPa	*Oedometric modulus*			

Description of natural soil surrounding the columns

h_w 1.5 m *Depth of Ground Water Table*

Priebe considers: $K_{0s} = 1$ *with K_{0s} : coefficient of earth pressure at rest*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	ν_s (-)	γ_s (kN/m^3)	M_s (kPa)	$Ø_c$ (m)	τ (%)	p_l* (kPa)
1	1.2	1.2	6,000	0.33	18	9,000	0.40	6.8%	400
2	1.2	1.3	6,000	0.33	18	9,000	0.40	6.8%	400
3	1.3	1.3	6,000	0.33	18	9,000	0.40	6.8%	400
4	1.3	1.3	6,000	0.33	18	9,000	0.40	6.8%	400
5	1.3	1.4	6,000	0.33	18	9,000	0.40	6.8%	400
6	1.4	1.4	6,000	0.33	18	9,000	0.40	6.8%	400
7	1.4	1.4	6,000	0.33	18	9,000	0.40	6.8%	400
8	1.4	1.4	6,000	0.33	18	9,000	0.40	6.8%	400
9	1.4	1.5	6,000	0.33	18	9,000	0.40	6.8%	400
10	1.5	1.5	6,000	0.33	18	9,000	0.40	6.8%	400

Description of natural soil below the columns

h_{lim} 10.0 m *Limit depth of model*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	ν_s (-)	M_s (kPa)
11	1.5	3.5	60,000	0.33	90,000
12	3.5	10.0	30,000	0.33	45,000

Notations

z_{sup}	*Depth of the top of the soil layer*	M_s	*Oedometric modulus in the layer*
z_{inf}	*Depth of the bottom of the soil layer*	$Ø_c$	*Stone Columns' diameter*
E_s	*Young's modulus in the layer*	τ	*Replacement ratio*
ν_s	*Poisson's coefficient*	p_l*	*Limit pressure in the layer*
γ_s	*Unit weight of the soil layer*		

Loading description at SLS

ΔQ	1,944 kN	*Load applied at the footing base*
Δq	150.0 kPa	*Pressure applied at the footing base*

UNIFORM LOADING

Hypothesis: columns are not compressible

Priebe suggests to use the following settlement reduction ratio, corresponding to an incompressible gravel:

$$\beta = 1 + \tau\left(\frac{f(\nu_s,\tau) + \frac{1}{2}}{f(\nu_s,\tau).K_{a_c}} - 1\right)$$

With:

$$f(\nu_s,\tau) = \frac{1-\nu_s^2}{1-\nu_s-2\nu_s^2}.\frac{(1-2\nu_s)(1-\tau)}{1-2\nu_s+\tau}$$

Values of the settlement reduction ratio, first step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	$f_0(\nu_s,\tau)$ (-)	β_0 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.2	1.2	1.55	1.3	114.5	636.9
2	1.2	1.3	1.55	1.3	114.5	636.9
3	1.3	1.3	1.55	1.3	114.5	636.9
4	1.3	1.3	1.55	1.3	114.5	636.9
5	1.3	1.4	1.55	1.3	114.5	636.9
6	1.4	1.4	1.55	1.3	114.5	636.9
7	1.4	1.4	1.55	1.3	114.5	636.9
8	1.4	1.4	1.55	1.3	114.5	636.9
9	1.4	1.5	1.55	1.3	114.5	636.9
10	1.5	1.5	1.55	1.3	114.5	636.9

Stress in soil and columns is assessed using the following formula:

$$\beta_0 = \frac{\Delta q}{\Delta q_s}$$

$$\Delta q = \tau.\Delta q_c + (1-\tau).\Delta q_s$$

Notations

Δq_s	*Additional stress on the soil*
Δq_c	*Additional stress in the column*

Column are made of compressible material

To take into account the fact that gravel is compressible, one should modify the replacement ratio value using the compressibility ratio column / soil.

Values of the settlement reduction ratio, second step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	M_c/M_s (-)	$\Delta(1/\tau)$ (-)	$\tau_{corrected}$ (%)	$f(\nu_s,\tau_{corrected})$ (-)	β_1 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.2	1.2	8.3	0.58	6.5%	1.56	1.3	115.6	621.9
2	1.2	1.3	8.3	0.58	6.5%	1.56	1.3	115.6	621.9
3	1.3	1.3	8.3	0.58	6.5%	1.56	1.3	115.6	621.9
4	1.3	1.3	8.3	0.58	6.5%	1.56	1.3	115.6	621.9
5	1.3	1.4	8.3	0.58	6.5%	1.56	1.3	115.6	621.9
6	1.4	1.4	8.3	0.58	6.5%	1.56	1.3	115.6	621.9
7	1.4	1.4	8.3	0.58	6.5%	1.56	1.3	115.6	621.9
8	1.4	1.4	8.3	0.58	6.5%	1.56	1.3	115.6	621.9
9	1.4	1.5	8.3	0.58	6.5%	1.56	1.3	115.6	621.9
10	1.5	1.5	8.3	0.58	6.5%	1.56	1.3	115.6	621.9

Notations

$\Delta(1/\tau)$	*Increase of 1 / τ*
$\tau_{corrected}$	*Modified value of replacement ratio*

Stress distribution per improved layer

The stress distribution ratio is:

$$n = \frac{\Delta q_C}{\Delta q_s} = \frac{f(\nu_s,\tau_{corrected}) + \frac{1}{2}}{f(\nu_s,\tau_{corrected}) \cdot K_{a_c}}$$

Layer n°	z_{sup} (m)	z_{inf} (m)	n (-)	$q_{c,0}$ (kPa)	Δq_c (kPa)	q_c (kPa)	$\Delta q_{c,max}$ (kPa)	Checking against bulging failure	$q_{s,0}$ (kPa)	Δq_s (kPa)	q_s (kPa)
1	1.2	1.2	5.5	21.9	621.9	643.8	800.0	OK	21.9	115.6	137.5
2	1.2	1.3	5.5	22.5	621.9	644.4	800.0	OK	22.4	115.6	138.1
3	1.3	1.3	5.5	23.1	621.9	645.0	800.0	OK	23.0	115.6	138.6
4	1.3	1.3	5.5	23.7	621.9	645.6	800.0	OK	23.5	115.6	139.1
5	1.3	1.4	5.5	24.3	621.9	646.2	800.0	OK	24.0	115.6	139.7
6	1.4	1.4	5.5	24.9	621.9	646.8	800.0	OK	24.6	115.6	140.2
7	1.4	1.4	5.5	25.5	621.9	647.4	800.0	OK	25.1	115.6	140.8
8	1.4	1.4	5.5	26.1	621.9	648.0	800.0	OK	25.7	115.6	141.3
9	1.4	1.5	5.5	26.7	621.9	648.6	800.0	OK	26.2	115.6	141.8
10	1.5	1.5	5.5	27.3	621.9	649.2	800.0	OK	26.7	115.6	142.4

Notations

$q_{c,0}$	*Initial effective vertical stress in the column*
q_c	*Final effective vertical stress in the column*
$\Delta q_{c,max}$	*Limit value as per DTU 13-2 (Fs = 2)*
$q_{s,0}$	*Initial effective vertical stress in the soil*
q_s	*Final effective vertical stress in the soil*

Depth correction factor

To take into account the additional lateral constraint due the earth pressure at depth, the settlement reduction ratio is multiplied by a coefficient f_d.

$$\beta_2 = f_d . \beta_1 \quad \text{and} \quad f_d = \frac{1}{1 + \frac{K_{0_c} - \frac{q_{s,0}}{q_{c,0}}}{K_{0_c}} . \frac{q_{c,0}}{\Delta q_c}} \quad \text{with} \quad f_d \geq 1$$

The coefficient f_d is limited by following formula: $$f_d \leq \frac{M_c}{M_s} . \frac{\Delta q_s}{\Delta q_c}$$

The settlement reduction ratio β_2 is limited by: $$\beta_{2,max} = 1 + \tau\left(\frac{M_c}{M_s} - 1\right)$$

Values of the settlement reduction ratio, step 3, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	f_d (-)	$f_{d,max}$ (-)	f_d (-)	β_2 (-)	$\beta_{2,max}$ (-)	β_2 (-)
1	1.2	1.2	1.1	1.5	1.1	1.4	1.5	1.4
2	1.2	1.3	1.1	1.5	1.1	1.4	1.5	1.4
3	1.3	1.3	1.1	1.5	1.1	1.4	1.5	1.4
4	1.3	1.3	1.1	1.5	1.1	1.4	1.5	1.4
5	1.3	1.4	1.1	1.5	1.1	1.4	1.5	1.4
6	1.4	1.4	1.1	1.5	1.1	1.4	1.5	1.4
7	1.4	1.4	1.1	1.5	1.1	1.4	1.5	1.4
8	1.4	1.4	1.1	1.5	1.1	1.4	1.5	1.4
9	1.4	1.5	1.1	1.5	1.1	1.4	1.5	1.4
10	1.5	1.5	1.1	1.5	1.1	1.4	1.5	1.4

Settlement distribution per layer

Over the length of the columns

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)	S_a (m)
1	1.2	1.2	0.001	0.000
2	1.2	1.3	0.001	0.000
3	1.3	1.3	0.001	0.000
4	1.3	1.3	0.000	0.000
5	1.3	1.4	0.001	0.000
6	1.4	1.4	0.001	0.000
7	1.4	1.4	0.001	0.000
8	1.4	1.4	0.001	0.000
9	1.4	1.5	0.001	0.000
10	1.5	1.5	0.001	0.000
		TOTAL	**0.005**	**0.004**

Notations

S_{na} Settlement of soil without soil improvement

S_a Settlement of soil with soil improvement

The total settlement in the soil w/o improvement under an uniform load is: **0.5 cm**

The settlement decrease ratio under an uniform load is: **1.4**

The total settlement of the improved soil under an uniform load is: **0.4 cm**

Below the improved soil layers

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)
11	1.5	3.5	0.003
12	3.5	10.0	0.022
		TOTAL	**0.025**

The settlement below the improved soil layers is: **2.5 cm**

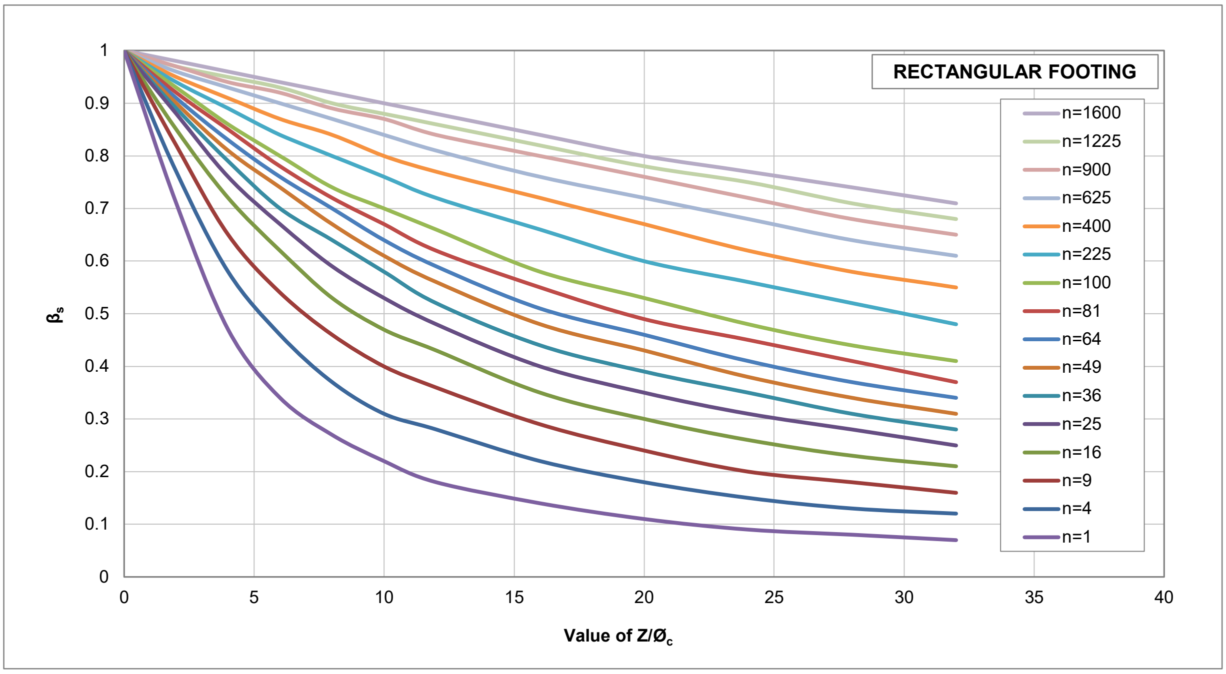
THE TOTAL SETTLEMENT OF THE SOIL UNDER AN UNIFORM LOAD IS **2.9 cm**

LOADING ON THE FOOTING

Settlement distribution

Over the length of the columns

This calculation is made by applying a new settlement reduction factor β_s to the settlement of the soil improved by stone columns.
Priebe has given a diagram of β_s values depending on the depth/diameter ratio $z/Ø_c$ and number of Stone Columns n.



The number of columns below the footing is: 7

The settlement of a layer at a depth Z below the base of the footing is determined as the difference of the settlements calculated between the lower bound Z_{inf} and the upper bound Z_{sup} of the concerned layer, with an average β_s calculated over the thickness of this layer:

$$S_{a,s}(z) = \frac{\Delta q}{M_s \beta_2}\left[(\beta_s)_{inf}.Z_{inf} - (\beta_s)_{sup}.Z_{sup}\right]$$

Layer n°	z sup (m)	z inf (m)	Z sup (m)	Z inf (m)	Z sup/Ø c (-)	Z inf/Ø c (-)	(β s) sup (-)	(β s) inf (-)	S a,s (m)
1	1.2	1.2	0.0	0.0	0.00	0.08	1.00	0.99	0.000
2	1.2	1.3	0.0	0.1	0.08	0.15	0.99	0.99	0.000
3	1.3	1.3	0.1	0.1	0.15	0.23	0.99	0.98	0.000
4	1.3	1.3	0.1	0.1	0.23	0.30	0.98	0.97	0.000
5	1.3	1.4	0.1	0.2	0.30	0.38	0.97	0.96	0.000
6	1.4	1.4	0.2	0.2	0.38	0.45	0.96	0.96	0.000
7	1.4	1.4	0.2	0.2	0.45	0.53	0.96	0.95	0.000
8	1.4	1.4	0.2	0.2	0.53	0.60	0.95	0.94	0.000
9	1.4	1.5	0.2	0.3	0.60	0.68	0.94	0.93	0.000
10	1.5	1.5	0.3	0.3	0.68	0.75	0.93	0.93	0.000
								TOTAL	**0.003**

The total settlement of the improved soil under the footing is: 0.3 cm

Notations

Z_{sup}	*Depth of the top of the soil layer from the foundation base*	$(\beta_s)_{sup}$	*Settlement reduction factor at the level of z_{sup}*
Z_{inf}	*Depth of the bottom of the soil layer from the foundation base*	$(\beta_s)_{inf}$	*Settlement reduction factor at the level of z_{inf}*
$S_{a,s}$	*Settlement of soil with soil improvement*		

Below the improved soil layers

Layer n°	z sup (m)	z inf (m)	S na,s (m)
11	1.5	3.5	0.003
12	3.5	10.0	0.005
		TOTAL	**0.007**

The settlement below the improved soil layers is: 0.7 cm

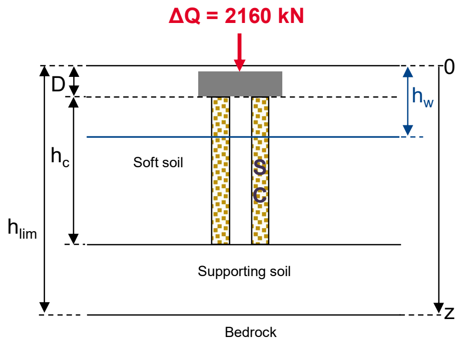
THE TOTAL SETTLEMENT OF THE SOIL BELOW THE FOOTING IS 1.1 cm

Project name: Poyle pad @150kPa
3.6m x 4.0m pad (X)

Area of the rectangular footing: 3.60 m x 4.00 m **Footing loaded at** ΔQ = 2,160.0 kN

DESIGN AS PER PRIEBE METHOD

Presentation of the model and main calculation results



Area of the footing = 14.4 m²

Diameter of the columns = 0.4 m to 0.4 m

Total settlement = 1.2 cm

Maximal stress within the columns = 618.1 kPa

Description of Stone Columns reinforcement

Description of the footing

Type of footing: **Rectangular**

L	3.6 m	*Length of the footing*		d	1.1 m	*Embedment height*
B	4 m	*Width of the footing*		$A_{footing}$	14.4 m²	*Area of the footing*

Number of columns under the footing: 8

Description of the stone columns

A	1.80 m²	*Equivalent grid area of the columns*	γ_c	20 kN/m³	*Unit weight of the gravel*
h_c	0.4 m	*Length of the columns*	φ_c	38 °	*Friction angle of the gravel*
E_c	50,000 kPa	*Young's modulus*	Ka_c	0.24	*Coefficient of active earth pressure*
v_c	0.33	*Poisson's coefficient*	K_{0c}	0.38	*Coefficient of earth pressure at rest*
M_c	75,000 kPa	*Oedometric modulus*			

Description of natural soil surrounding the columns

h_w 1.5 m *Depth of Ground Water Table*

Priebe considers: $K_{0s} = 1$ *with K_{0s} : coefficient of earth pressure at rest*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	v_s (-)	γ_s (kN/m³)	M_s (kPa)	$Ø_c$ (m)	τ (%)	p_l* (kPa)
1	1.1	1.1	6,000	0.33	18	9,000	0.40	7.0%	400
2	1.1	1.2	6,000	0.33	18	9,000	0.40	7.0%	400
3	1.2	1.2	6,000	0.33	18	9,000	0.40	7.0%	400
4	1.2	1.3	6,000	0.33	18	9,000	0.40	7.0%	400
5	1.3	1.3	6,000	0.33	18	9,000	0.40	7.0%	400
6	1.3	1.3	6,000	0.33	18	9,000	0.40	7.0%	400
7	1.3	1.4	6,000	0.33	18	9,000	0.40	7.0%	400
8	1.4	1.4	6,000	0.33	18	9,000	0.40	7.0%	400
9	1.4	1.5	6,000	0.33	18	9,000	0.40	7.0%	400
10	1.5	1.5	6,000	0.33	18	9,000	0.40	7.0%	400

Description of natural soil below the columns

h_{lim} 10.0 m *Limit depth of model*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	v_s (-)	M_s (kPa)
11	1.5	3.5	60,000	0.33	90,000
12	3.5	10.0	30,000	0.33	45,000

Notations

z_{sup}	*Depth of the top of the soil layer*	M_s	*Oedometric modulus in the layer*
z_{inf}	*Depth of the bottom of the soil layer*	$Ø_c$	*Stone Columns' diameter*
E_s	*Young's modulus in the layer*	τ	*Replacement ratio*
v_s	*Poisson's coefficient*	p_l*	*Limit pressure in the layer*
γ_s	*Unit weight of the soil layer*		

Loading description at SLS

ΔQ	2,160 kN	*Load applied at the footing base*
Δq	150.0 kPa	*Pressure applied at the footing base*

UNIFORM LOADING

Hypothesis: columns are not compressible

Priebe suggests to use the following settlement reduction ratio, corresponding to an incompressible gravel:

$$\beta = 1 + \tau\left(\frac{f(\nu_s,\tau) + \frac{1}{2}}{f(\nu_s,\tau).K_{a_c}} - 1\right)$$

With:

$$f(\nu_s,\tau) = \frac{1-\nu_s^2}{1-\nu_s-2\nu_s^2}\cdot\frac{(1-2\nu_s)(1-\tau)}{1-2\nu_s+\tau}$$

Values of the settlement reduction ratio, first step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	$f_0(\nu_s,\tau)$ (-)	β_0 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.1	1.1	1.54	1.3	113.7	633.4
2	1.1	1.2	1.54	1.3	113.7	633.4
3	1.2	1.2	1.54	1.3	113.7	633.4
4	1.2	1.3	1.54	1.3	113.7	633.4
5	1.3	1.3	1.54	1.3	113.7	633.4
6	1.3	1.3	1.54	1.3	113.7	633.4
7	1.3	1.4	1.54	1.3	113.7	633.4
8	1.4	1.4	1.54	1.3	113.7	633.4
9	1.4	1.5	1.54	1.3	113.7	633.4
10	1.5	1.5	1.54	1.3	113.7	633.4

Stress in soil and columns is assessed using the following formula:

$$\beta_0 = \frac{\Delta q}{\Delta q_s}$$

$$\Delta q = \tau.\Delta q_c + (1-\tau).\Delta q_s$$

Notations

Δq_s	*Additional stress on the soil*
Δq_c	*Additional stress in the column*

Column are made of compressible material

To take into account the fact that gravel is compressible, one should modify the replacement ratio value using the compressibility ratio column / soil.

Values of the settlement reduction ratio, second step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	M_c/M_s (-)	$\Delta(1/\tau)$ (-)	$\tau_{corrected}$ (%)	$f(\nu_s,\tau_{corrected})$ (-)	β_1 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.1	1.1	8.3	0.58	6.7%	1.55	1.3	114.9	618.1
2	1.1	1.2	8.3	0.58	6.7%	1.55	1.3	114.9	618.1
3	1.2	1.2	8.3	0.58	6.7%	1.55	1.3	114.9	618.1
4	1.2	1.3	8.3	0.58	6.7%	1.55	1.3	114.9	618.1
5	1.3	1.3	8.3	0.58	6.7%	1.55	1.3	114.9	618.1
6	1.3	1.3	8.3	0.58	6.7%	1.55	1.3	114.9	618.1
7	1.3	1.4	8.3	0.58	6.7%	1.55	1.3	114.9	618.1
8	1.4	1.4	8.3	0.58	6.7%	1.55	1.3	114.9	618.1
9	1.4	1.5	8.3	0.58	6.7%	1.55	1.3	114.9	618.1
10	1.5	1.5	8.3	0.58	6.7%	1.55	1.3	114.9	618.1

Notations

$\Delta(1/\tau)$	*Increase of 1 / τ*
$\tau_{corrected}$	*Modified value of replacement ratio*

Stress distribution per improved layer

The stress distribution ratio is:

$$n = \frac{\Delta q_C}{\Delta q_S} = \frac{f(\nu_s,\tau_{corrected}) + \frac{1}{2}}{f(\nu_s,\tau_{corrected})\cdot K_{a_c}}$$

Layer n°	z_{sup} (m)	z_{inf} (m)	n (-)	$q_{c,0}$ (kPa)	Δq_c (kPa)	q_c (kPa)	$\Delta q_{c,max}$ (kPa)	Checking against bulging failure	$q_{s,0}$ (kPa)	Δq_s (kPa)	q_s (kPa)
1	1.1	1.1	5.6	20.2	618.1	638.3	800.0	OK	20.2	114.9	135.0
2	1.1	1.2	5.6	21.0	618.1	639.1	800.0	OK	20.9	114.9	135.7
3	1.2	1.2	5.6	21.8	618.1	639.9	800.0	OK	21.6	114.9	136.5
4	1.2	1.3	5.6	22.6	618.1	640.7	800.0	OK	22.3	114.9	137.2
5	1.3	1.3	5.6	23.4	618.1	641.5	800.0	OK	23.0	114.9	137.9
6	1.3	1.3	5.6	24.2	618.1	642.3	800.0	OK	23.8	114.9	138.6
7	1.3	1.4	5.6	25.0	618.1	643.1	800.0	OK	24.5	114.9	139.3
8	1.4	1.4	5.6	25.8	618.1	643.9	800.0	OK	25.2	114.9	140.1
9	1.4	1.5	5.6	26.6	618.1	644.7	800.0	OK	25.9	114.9	140.8
10	1.5	1.5	5.6	27.4	618.1	645.5	800.0	OK	26.6	114.9	141.5

Notations

$q_{c,0}$	*Initial effective vertical stress in the column*	$q_{s,0}$	*Initial effective vertical stress in the soil*
q_c	*Final effective vertical stress in the column*	q_s	*Final effective vertical stress in the soil*
$\Delta q_{c,max}$	*Limit value as per DTU 13-2 (Fs = 2)*		

Depth correction factor

To take into account the additional lateral constraint due the earth pressure at depth, the settlement reduction ratio is multiplied by a coefficient f_d.

$$\beta_2 = f_d . \beta_1 \quad \textit{and} \quad f_d = \frac{1}{1 + \frac{K_{0_c} - \frac{q_{s,0}}{q_{c,0}}}{K_{0_c}} . \frac{q_{c,0}}{\Delta q_c}} \quad \textit{with} \quad f_d \geq 1$$

The coefficient f_d is limited by following formula: $$f_d \leq \frac{M_c}{M_s} . \frac{\Delta q_s}{\Delta q_c}$$

The settlement reduction ratio β_2 is limited by: $$\beta_{2,max} = 1 + \tau \left(\frac{M_c}{M_s} - 1 \right)$$

Values of the settlement reduction ratio, step 3, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	f_d (-)	$f_{d,max}$ (-)	f_d (-)	β_2 (-)	$\beta_{2,max}$ (-)	β_2 (-)
1	1.1	1.1	1.1	1.5	1.1	1.4	1.5	1.4
2	1.1	1.2	1.1	1.5	1.1	1.4	1.5	1.4
3	1.2	1.2	1.1	1.5	1.1	1.4	1.5	1.4
4	1.2	1.3	1.1	1.5	1.1	1.4	1.5	1.4
5	1.3	1.3	1.1	1.5	1.1	1.4	1.5	1.4
6	1.3	1.3	1.1	1.5	1.1	1.4	1.5	1.4
7	1.3	1.4	1.1	1.5	1.1	1.4	1.5	1.4
8	1.4	1.4	1.1	1.5	1.1	1.4	1.5	1.4
9	1.4	1.5	1.1	1.5	1.1	1.4	1.5	1.4
10	1.5	1.5	1.1	1.5	1.1	1.4	1.5	1.4

Settlement distribution per layer

Over the length of the columns

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)	S_a (m)
1	1.1	1.1	0.001	0.000
2	1.1	1.2	0.001	0.000
3	1.2	1.2	0.001	0.000
4	1.2	1.3	0.001	0.000
5	1.3	1.3	0.001	0.000
6	1.3	1.3	0.001	0.000
7	1.3	1.4	0.001	0.000
8	1.4	1.4	0.001	0.000
9	1.4	1.5	0.001	0.000
10	1.5	1.5	0.001	0.000
		TOTAL	**0.007**	**0.005**

Notations

S_{na}	*Settlement of soil without soil improvement*
S_a	*Settlement of soil with soil improvement*

The total settlement in the soil w/o improvement under an uniform load is: **0.7 cm**

The settlement decrease ratio under an uniform load is: **1.4**

The total settlement of the improved soil under an uniform load is: **0.5 cm**

Below the improved soil layers

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)
11	1.5	3.5	0.003
12	3.5	10.0	0.022
		TOTAL	**0.025**

The settlement below the improved soil layers is: **2.5 cm**

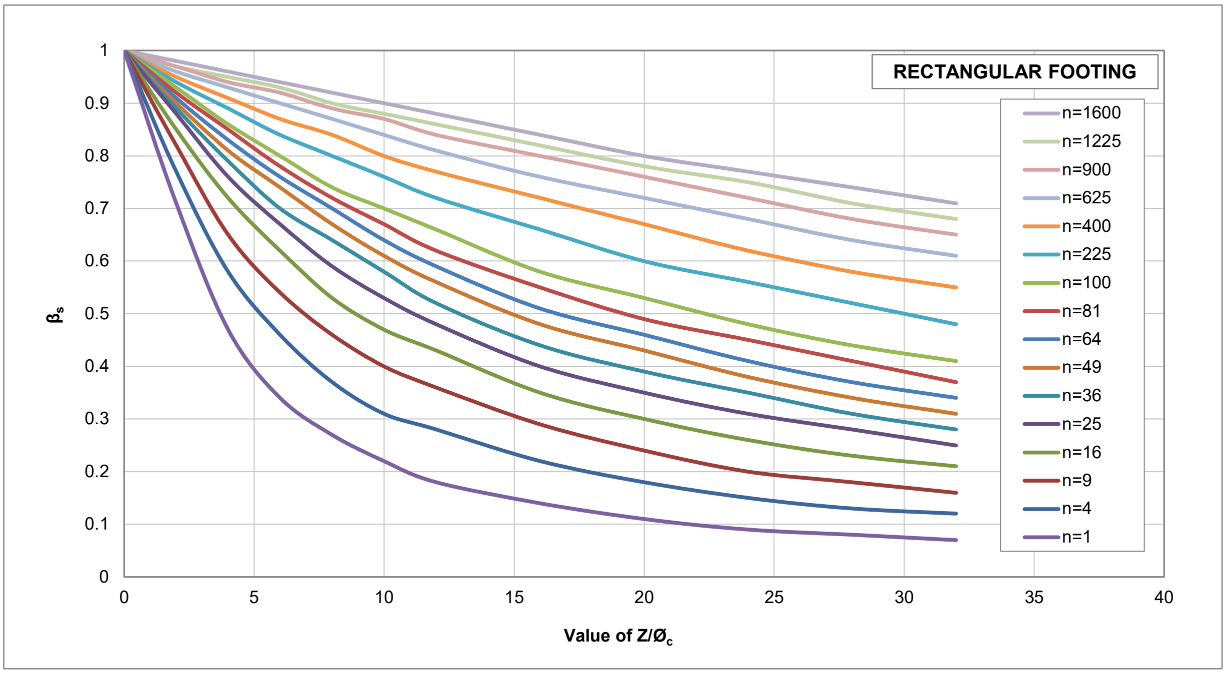
THE TOTAL SETTLEMENT OF THE SOIL UNDER AN UNIFORM LOAD IS **3.0 cm**

LOADING ON THE FOOTING

Settlement distribution

Over the length of the columns

This calculation is made by applying a new settlement reduction factor β_s to the settlement of the soil improved by stone columns. Priebe has given a diagram of β_s values depending on the depth/diameter ratio $z/Ø_c$ and number of Stone Columns n.



The number of columns below the footing is: 8

The settlement of a layer at a depth Z below the base of the footing is determined as the difference of the settlements calculated between the lower bound Z_{inf} and the upper bound Z_{sup} of the concerned layer, with an average β_s calculated over the thickness of this layer:

$$S_{a,s}(z) = \frac{\Delta q}{M_s \beta_2}[(\beta_s)_{inf}.Z_{inf} - (\beta_s)_{sup}.Z_{sup}]$$

Layer n°	z sup (m)	z inf (m)	Z sup (m)	Z inf (m)	Z sup/Ø c (-)	Z inf/Ø c (-)	(β s) sup (-)	(β s) inf (-)	S a,s (m)
1	1.1	1.1	0.0	0.0	0.00	0.10	1.00	0.99	0.000
2	1.1	1.2	0.0	0.1	0.10	0.20	0.99	0.98	0.000
3	1.2	1.2	0.1	0.1	0.20	0.30	0.98	0.97	0.000
4	1.2	1.3	0.1	0.2	0.30	0.40	0.97	0.96	0.000
5	1.3	1.3	0.2	0.2	0.40	0.50	0.96	0.95	0.000
6	1.3	1.3	0.2	0.2	0.50	0.60	0.95	0.94	0.000
7	1.3	1.4	0.2	0.3	0.60	0.70	0.94	0.93	0.000
8	1.4	1.4	0.3	0.3	0.70	0.80	0.93	0.92	0.000
9	1.4	1.5	0.3	0.4	0.80	0.90	0.92	0.91	0.000
10	1.5	1.5	0.4	0.4	0.90	1.00	0.91	0.91	0.000
								TOTAL	**0.004**

The total settlement of the improved soil under the footing is: 0.4 cm

Notations

Z_{sup}	*Depth of the top of the soil layer from the foundation base*	$(\beta_s)_{sup}$	*Settlement reduction factor at the level of z_{sup}*
Z_{inf}	*Depth of the bottom of the soil layer from the foundation base*	$(\beta_s)_{inf}$	*Settlement reduction factor at the level of z_{inf}*
$S_{a,s}$	*Settlement of soil with soil improvement*		

Below the improved soil layers

Layer n°	z sup (m)	z inf (m)	S na,s (m)
11	1.5	3.5	0.003
12	3.5	10.0	0.005
		TOTAL	**0.008**

The settlement below the improved soil layers is: 0.8 cm

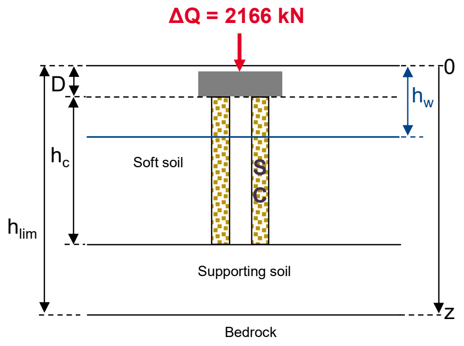
THE TOTAL SETTLEMENT OF THE SOIL BELOW THE FOOTING IS 1.2 cm

Project name: *Poyle pad @150kPa*
3.8m x 3.8m pad (L)

Area of the rectangular footing: *3.80 m x 3.80 m* ***Footing loaded at*** *ΔQ = 2,166.0 kN*

DESIGN AS PER PRIEBE METHOD

Presentation of the model and main calculation results



Area of the footing = 14.44 m²

Diameter of the columns = 0.4 m to 0.4 m

Total settlement = 1.1 cm

Maximal stress within the columns = 618.5 kPa

Description of Stone Columns reinforcement

Description of the footing

Type of footing: **Rectangular**

L	3.8 m	*Length of the footing*	d	1.2 m	*Embedment height*
B	3.8 m	*Width of the footing*	$A_{footing}$	14.44 m²	*Area of the footing*

Number of columns under the footing: **8**

Description of the stone columns

A	1.81 m²	*Equivalent grid area of the columns*	γ_c	20 kN/m^3	*Unit weight of the gravel*
h_c	0.3 m	*Length of the columns*	φ_c	38 °	*Friction angle of the gravel*
E_c	50,000 kPa	*Young's modulus*	Ka_c	0.24	*Coefficient of active earth pressure*
ν_c	0.33	*Poisson's coefficient*	K_{0c}	0.38	*Coefficient of earth pressure at rest*
M_c	75,000 kPa	*Oedometric modulus*			

Description of natural soil surrounding the columns

h_w 1.5 m *Depth of Ground Water Table*

Priebe considers: $K_{0s} = 1$ *with K_{0s} : coefficient of earth pressure at rest*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	ν_s (-)	γ_s (kN/m^3)	M_s (kPa)	$Ø_c$ (m)	τ (%)	p_l* (kPa)
1	1.2	1.2	6,000	0.33	18	9,000	0.40	7.0%	400
2	1.2	1.3	6,000	0.33	18	9,000	0.40	7.0%	400
3	1.3	1.3	6,000	0.33	18	9,000	0.40	7.0%	400
4	1.3	1.3	6,000	0.33	18	9,000	0.40	7.0%	400
5	1.3	1.4	6,000	0.33	18	9,000	0.40	7.0%	400
6	1.4	1.4	6,000	0.33	18	9,000	0.40	7.0%	400
7	1.4	1.4	6,000	0.33	18	9,000	0.40	7.0%	400
8	1.4	1.4	6,000	0.33	18	9,000	0.40	7.0%	400
9	1.4	1.5	6,000	0.33	18	9,000	0.40	7.0%	400
10	1.5	1.5	6,000	0.33	18	9,000	0.40	7.0%	400

Description of natural soil below the columns

h_{lim} 10.0 m *Limit depth of model*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	ν_s (-)	M_s (kPa)
11	1.5	3.5	60,000	0.33	90,000
12	3.5	10.0	30,000	0.33	45,000

Notations

z_{sup}	*Depth of the top of the soil layer*	M_s	*Oedometric modulus in the layer*
z_{inf}	*Depth of the bottom of the soil layer*	$Ø_c$	*Stone Columns' diameter*
E_s	*Young's modulus in the layer*	τ	*Replacement ratio*
ν_s	*Poisson's coefficient*	p_l*	*Limit pressure in the layer*
γ_s	*Unit weight of the soil layer*		

Loading description at SLS

ΔQ	2,166 kN	*Load applied at the footing base*
Δq	150.0 kPa	*Pressure applied at the footing base*

UNIFORM LOADING

Hypothesis: columns are not compressible

Priebe suggests to use the following settlement reduction ratio, corresponding to an incompressible gravel:

$$\beta = 1 + \tau\left(\frac{f(\nu_s,\tau) + \frac{1}{2}}{f(\nu_s,\tau).K_{a_c}} - 1\right)$$

With:

$$f(\nu_s,\tau) = \frac{1-\nu_s^2}{1-\nu_s-2\nu_s^2}\cdot\frac{(1-2\nu_s)(1-\tau)}{1-2\nu_s+\tau}$$

Values of the settlement reduction ratio, first step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	$f_0(\nu_s,\tau)$ (-)	β_0 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.2	1.2	1.54	1.3	113.8	633.8
2	1.2	1.3	1.54	1.3	113.8	633.8
3	1.3	1.3	1.54	1.3	113.8	633.8
4	1.3	1.3	1.54	1.3	113.8	633.8
5	1.3	1.4	1.54	1.3	113.8	633.8
6	1.4	1.4	1.54	1.3	113.8	633.8
7	1.4	1.4	1.54	1.3	113.8	633.8
8	1.4	1.4	1.54	1.3	113.8	633.8
9	1.4	1.5	1.54	1.3	113.8	633.8
10	1.5	1.5	1.54	1.3	113.8	633.8

Stress in soil and columns is assessed using the following formula:

$$\beta_0 = \frac{\Delta q}{\Delta q_s}$$

$$\Delta q = \tau.\Delta q_c + (1-\tau).\Delta q_s$$

Notations

Δq_s	*Additional stress on the soil*
Δq_c	*Additional stress in the column*

Column are made of compressible material

To take into account the fact that gravel is compressible, one should modify the replacement ratio value using the compressibility ratio column / soil.

Values of the settlement reduction ratio, second step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	M_c/M_s (-)	$\Delta(1/\tau)$ (-)	$\tau_{corrected}$ (%)	$f(\nu_s,\tau_{corrected})$ (-)	β_1 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.2	1.2	8.3	0.58	6.7%	1.55	1.3	114.9	618.5
2	1.2	1.3	8.3	0.58	6.7%	1.55	1.3	114.9	618.5
3	1.3	1.3	8.3	0.58	6.7%	1.55	1.3	114.9	618.5
4	1.3	1.3	8.3	0.58	6.7%	1.55	1.3	114.9	618.5
5	1.3	1.4	8.3	0.58	6.7%	1.55	1.3	114.9	618.5
6	1.4	1.4	8.3	0.58	6.7%	1.55	1.3	114.9	618.5
7	1.4	1.4	8.3	0.58	6.7%	1.55	1.3	114.9	618.5
8	1.4	1.4	8.3	0.58	6.7%	1.55	1.3	114.9	618.5
9	1.4	1.5	8.3	0.58	6.7%	1.55	1.3	114.9	618.5
10	1.5	1.5	8.3	0.58	6.7%	1.55	1.3	114.9	618.5

Notations

$\Delta(1/\tau)$	*Increase of 1 / τ*
$\tau_{corrected}$	*Modified value of replacement ratio*

Stress distribution per improved layer

The stress distribution ratio is:

$$n = \frac{\Delta q_C}{\Delta q_S} = \frac{f(\nu_s,\tau_{corrected}) + \frac{1}{2}}{f(\nu_s,\tau_{corrected})\cdot K_{a_c}}$$

Layer n°	z_{sup} (m)	z_{inf} (m)	n (-)	$q_{c,0}$ (kPa)	Δq_c (kPa)	q_c (kPa)	$\Delta q_{c,max}$ (kPa)	Checking against bulging failure	$q_{s,0}$ (kPa)	Δq_s (kPa)	q_s (kPa)
1	1.2	1.2	5.6	21.9	618.5	640.4	800.0	OK	21.9	114.9	136.8
2	1.2	1.3	5.6	22.5	618.5	641.0	800.0	OK	22.4	114.9	137.4
3	1.3	1.3	5.6	23.1	618.5	641.6	800.0	OK	23.0	114.9	137.9
4	1.3	1.3	5.6	23.7	618.5	642.2	800.0	OK	23.5	114.9	138.4
5	1.3	1.4	5.6	24.3	618.5	642.8	800.0	OK	24.0	114.9	139.0
6	1.4	1.4	5.6	24.9	618.5	643.4	800.0	OK	24.6	114.9	139.5
7	1.4	1.4	5.6	25.5	618.5	644.0	800.0	OK	25.1	114.9	140.1
8	1.4	1.4	5.6	26.1	618.5	644.6	800.0	OK	25.7	114.9	140.6
9	1.4	1.5	5.6	26.7	618.5	645.2	800.0	OK	26.2	114.9	141.1
10	1.5	1.5	5.6	27.3	618.5	645.8	800.0	OK	26.7	114.9	141.7

Notations

$q_{c,0}$	*Initial effective vertical stress in the column*
q_c	*Final effective vertical stress in the column*
$\Delta q_{c,max}$	*Limit value as per DTU 13-2 (Fs = 2)*
$q_{s,0}$	*Initial effective vertical stress in the soil*
q_s	*Final effective vertical stress in the soil*

Depth correction factor

To take into account the additional lateral constraint due the earth pressure at depth, the settlement reduction ratio is multiplied by a coefficient f_d.

$$\beta_2 = f_d . \beta_1 \quad \text{and} \quad f_d = \frac{1}{1 + \frac{K_{0_c} - \frac{q_{s,0}}{q_{c,0}}}{K_{0_c}} . \frac{q_{c,0}}{\Delta q_c}} \quad \text{with} \quad f_d \geq 1$$

The coefficient f_d is limited by following formula:

$$f_d \leq \frac{M_c}{M_s} . \frac{\Delta q_s}{\Delta q_c}$$

The settlement reduction ratio β_2 is limited by:

$$\beta_{2,max} = 1 + \tau\left(\frac{M_c}{M_s} - 1\right)$$

Values of the settlement reduction ratio, step 3, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	f_d (-)	$f_{d,max}$ (-)	f_d (-)	β_2 (-)	$\beta_{2,max}$ (-)	β_2 (-)
1	1.2	1.2	1.1	1.5	1.1	1.4	1.5	1.4
2	1.2	1.3	1.1	1.5	1.1	1.4	1.5	1.4
3	1.3	1.3	1.1	1.5	1.1	1.4	1.5	1.4
4	1.3	1.3	1.1	1.5	1.1	1.4	1.5	1.4
5	1.3	1.4	1.1	1.5	1.1	1.4	1.5	1.4
6	1.4	1.4	1.1	1.5	1.1	1.4	1.5	1.4
7	1.4	1.4	1.1	1.5	1.1	1.4	1.5	1.4
8	1.4	1.4	1.1	1.5	1.1	1.4	1.5	1.4
9	1.4	1.5	1.1	1.5	1.1	1.4	1.5	1.4
10	1.5	1.5	1.1	1.5	1.1	1.4	1.5	1.4

Settlement distribution per layer

Over the length of the columns

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)	S_a (m)
1	1.2	1.2	0.001	0.000
2	1.2	1.3	0.001	0.000
3	1.3	1.3	0.001	0.000
4	1.3	1.3	0.000	0.000
5	1.3	1.4	0.001	0.000
6	1.4	1.4	0.001	0.000
7	1.4	1.4	0.001	0.000
8	1.4	1.4	0.001	0.000
9	1.4	1.5	0.001	0.000
10	1.5	1.5	0.001	0.000
		TOTAL	**0.005**	**0.004**

Notations

S_{na} *Settlement of soil without soil improvement*

S_a *Settlement of soil with soil improvement*

The total settlement in the soil w/o improvement under an uniform load is: 0.5 cm

The settlement decrease ratio under an uniform load is: 1.4

The total settlement of the improved soil under an uniform load is: 0.4 cm

Below the improved soil layers

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)
11	1.5	3.5	0.003
12	3.5	10.0	0.022
		TOTAL	**0.025**

The settlement below the improved soil layers is: 2.5 cm

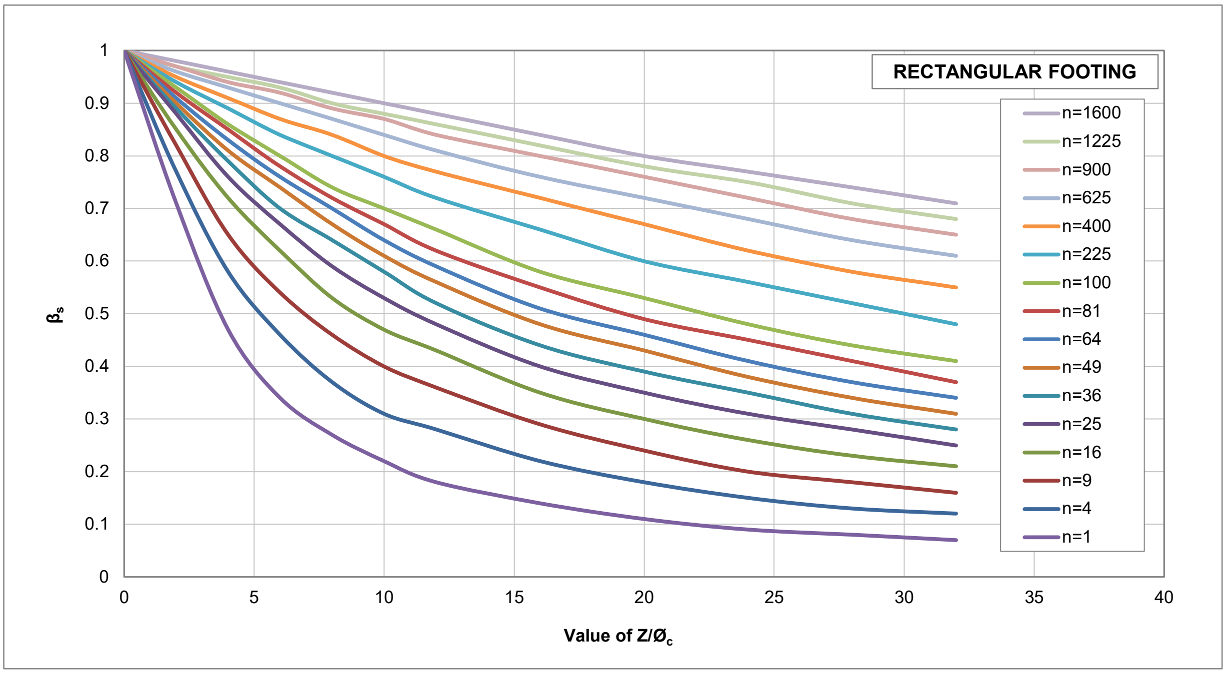
THE TOTAL SETTLEMENT OF THE SOIL UNDER AN UNIFORM LOAD IS 2.9 cm

LOADING ON THE FOOTING

Settlement distribution

Over the length of the columns

This calculation is made by applying a new settlement reduction factor β_s to the settlement of the soil improved by stone columns.
Priebe has given a diagram of β_s values depending on the depth/diameter ratio $z/Ø_c$ and number of Stone Columns n.



The number of columns below the footing is: 8

The settlement of a layer at a depth Z below the base of the footing is determined as the difference of the settlements calculated between the lower bound Z_{inf} and the upper bound Z_{sup} of the concerned layer, with an average β_s calculated over the thickness of this layer:

$$S_{a,s}(z) = \frac{\Delta q}{M_s \beta_2}\left[(\beta_s)_{inf}.Z_{inf} - (\beta_s)_{sup}.Z_{sup}\right]$$

Layer n°	z sup (m)	z inf (m)	Z sup (m)	Z inf (m)	Z sup/Ø c (-)	Z inf/Ø c (-)	(β s) sup (-)	(β s) inf (-)	S a,s (m)
1	1.2	1.2	0.0	0.0	0.00	0.08	1.00	0.99	0.000
2	1.2	1.3	0.0	0.1	0.08	0.15	0.99	0.99	0.000
3	1.3	1.3	0.1	0.1	0.15	0.23	0.99	0.98	0.000
4	1.3	1.3	0.1	0.1	0.23	0.30	0.98	0.97	0.000
5	1.3	1.4	0.1	0.2	0.30	0.38	0.97	0.96	0.000
6	1.4	1.4	0.2	0.2	0.38	0.45	0.96	0.96	0.000
7	1.4	1.4	0.2	0.2	0.45	0.53	0.96	0.95	0.000
8	1.4	1.4	0.2	0.2	0.53	0.60	0.95	0.94	0.000
9	1.4	1.5	0.2	0.3	0.60	0.68	0.94	0.94	0.000
10	1.5	1.5	0.3	0.3	0.68	0.75	0.94	0.93	0.000
								TOTAL	**0.003**

The total settlement of the improved soil under the footing is: 0.3 cm

Notations

Z_{sup}	*Depth of the top of the soil layer from the foundation base*	$(\beta_s)_{sup}$	*Settlement reduction factor at the level of z_{sup}*
Z_{inf}	*Depth of the bottom of the soil layer from the foundation base*	$(\beta_s)_{inf}$	*Settlement reduction factor at the level of z_{inf}*
$S_{a,s}$	*Settlement of soil with soil improvement*		

Below the improved soil layers

Layer n°	z sup (m)	z inf (m)	S na,s (m)
11	1.5	3.5	0.003
12	3.5	10.0	0.005
		TOTAL	**0.008**

The settlement below the improved soil layers is: 0.8 cm

THE TOTAL SETTLEMENT OF THE SOIL BELOW THE FOOTING IS 1.1 cm

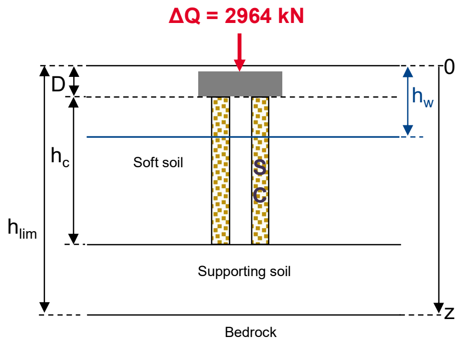
menard

Project name: Poyle pad @150kPa
4.4m x 4.4m pad (C)

Area of the rectangular footing: 3.80 m x 5.20 m **Footing loaded at** ΔQ = 2,964.0 kN

DESIGN AS PER PRIEBE METHOD

Presentation of the model and main calculation results



Area of the footing = 19.76 m²

Diameter of the columns = 0.4 m to 0.4 m

Total settlement = 1.3 cm

Maximal stress within the columns = 630.3 kPa

Description of Stone Columns reinforcement

Description of the footing

Type of footing: **Rectangular**

L	3.8 m	*Length of the footing*	d	1.1 m	*Embedment height*
B	5.2 m	*Width of the footing*	$A_{footing}$	19.76 m²	*Area of the footing*

Number of columns under the footing: 10

Description of the stone columns

A	1.98 m²	*Equivalent grid area of the columns*	γ_c	20 kN/m³	*Unit weight of the gravel*
h_c	0.4 m	*Length of the columns*	φ_c	38 °	*Friction angle of the gravel*
E_c	50,000 kPa	*Young's modulus*	Ka_c	0.24	*Coefficient of active earth pressure*
ν_c	0.33	*Poisson's coefficient*	K_{0c}	0.38	*Coefficient of earth pressure at rest*
M_c	75,000 kPa	*Oedometric modulus*			

Description of natural soil surrounding the columns

h_w 1.5 m *Depth of Ground Water Table*

Priebe considers: $K_{0s} = 1$ *with K_{0s} : coefficient of earth pressure at rest*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	ν_s (-)	γ_s (kN/m³)	M_s (kPa)	$Ø_c$ (m)	τ (%)	p_l^* (kPa)
1	1.1	1.1	6,000	0.33	18	9,000	0.40	6.4%	400
2	1.1	1.2	6,000	0.33	18	9,000	0.40	6.4%	400
3	1.2	1.2	6,000	0.33	18	9,000	0.40	6.4%	400
4	1.2	1.3	6,000	0.33	18	9,000	0.40	6.4%	400
5	1.3	1.3	6,000	0.33	18	9,000	0.40	6.4%	400
6	1.3	1.3	6,000	0.33	18	9,000	0.40	6.4%	400
7	1.3	1.4	6,000	0.33	18	9,000	0.40	6.4%	400
8	1.4	1.4	6,000	0.33	18	9,000	0.40	6.4%	400
9	1.4	1.5	6,000	0.33	18	9,000	0.40	6.4%	400
10	1.5	1.5	6,000	0.33	18	9,000	0.40	6.4%	400

Description of natural soil below the columns

h_{lim} 10.0 m *Limit depth of model*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	ν_s (-)	M_s (kPa)
11	1.5	3.5	60,000	0.33	90,000
12	3.5	10.0	30,000	0.33	45,000

Notations

z_{sup}	*Depth of the top of the soil layer*	M_s	*Oedometric modulus in the layer*
z_{inf}	*Depth of the bottom of the soil layer*	$Ø_c$	*Stone Columns' diameter*
E_s	*Young's modulus in the layer*	τ	*Replacement ratio*
ν_s	*Poisson's coefficient*	p_l^*	*Limit pressure in the layer*
γ_s	*Unit weight of the soil layer*		

Loading description at SLS

ΔQ	2,964 kN	*Load applied at the footing base*
Δq	150.0 kPa	*Pressure applied at the footing base*

UNIFORM LOADING

Hypothesis: columns are not compressible

Priebe suggests to use the following settlement reduction ratio, corresponding to an incompressible gravel:

$$\beta = 1 + \tau\left(\frac{f(\nu_s,\tau) + \frac{1}{2}}{f(\nu_s,\tau).K_{a_c}} - 1\right)$$

With:

$$f(\nu_s,\tau) = \frac{1-\nu_s^2}{1-\nu_s-2\nu_s^2}.\frac{(1-2\nu_s)(1-\tau)}{1-2\nu_s+\tau}$$

Values of the settlement reduction ratio, first step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	$f_0(\nu_s,\tau)$ (-)	β_0 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.1	1.1	1.57	1.3	116.4	644.8
2	1.1	1.2	1.57	1.3	116.4	644.8
3	1.2	1.2	1.57	1.3	116.4	644.8
4	1.2	1.3	1.57	1.3	116.4	644.8
5	1.3	1.3	1.57	1.3	116.4	644.8
6	1.3	1.3	1.57	1.3	116.4	644.8
7	1.3	1.4	1.57	1.3	116.4	644.8
8	1.4	1.4	1.57	1.3	116.4	644.8
9	1.4	1.5	1.57	1.3	116.4	644.8
10	1.5	1.5	1.57	1.3	116.4	644.8

Stress in soil and columns is assessed using the following formula:

$$\beta_0 = \frac{\Delta q}{\Delta q_s}$$

$$\Delta q = \tau.\Delta q_c + (1-\tau).\Delta q_s$$

Notations

Δq_s	*Additional stress on the soil*
Δq_c	*Additional stress in the column*

Column are made of compressible material

To take into account the fact that gravel is compressible, one should modify the replacement ratio value using the compressibility ratio column / soil.

Values of the settlement reduction ratio, second step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	M_c/M_s (-)	$\Delta(1/\tau)$ (-)	$\tau_{corrected}$ (%)	$f(\nu_s,\tau_{corrected})$ (-)	β_1 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.1	1.1	8.3	0.58	6.1%	1.59	1.3	117.4	630.3
2	1.1	1.2	8.3	0.58	6.1%	1.59	1.3	117.4	630.3
3	1.2	1.2	8.3	0.58	6.1%	1.59	1.3	117.4	630.3
4	1.2	1.3	8.3	0.58	6.1%	1.59	1.3	117.4	630.3
5	1.3	1.3	8.3	0.58	6.1%	1.59	1.3	117.4	630.3
6	1.3	1.3	8.3	0.58	6.1%	1.59	1.3	117.4	630.3
7	1.3	1.4	8.3	0.58	6.1%	1.59	1.3	117.4	630.3
8	1.4	1.4	8.3	0.58	6.1%	1.59	1.3	117.4	630.3
9	1.4	1.5	8.3	0.58	6.1%	1.59	1.3	117.4	630.3
10	1.5	1.5	8.3	0.58	6.1%	1.59	1.3	117.4	630.3

Notations

$\Delta(1/\tau)$	*Increase of 1 / τ*
$\tau_{corrected}$	*Modified value of replacement ratio*

Stress distribution per improved layer

The stress distribution ratio is:

$$n = \frac{\Delta q_C}{\Delta q_S} = \frac{f(\nu_s,\tau_{corrected}) + \frac{1}{2}}{f(\nu_s,\tau_{corrected}) \cdot K_{a_c}}$$

Layer n°	z_{sup} (m)	z_{inf} (m)	n (-)	$q_{c,0}$ (kPa)	Δq_c (kPa)	q_c (kPa)	$\Delta q_{c,max}$ (kPa)	Checking against bulging failure	$q_{s,0}$ (kPa)	Δq_s (kPa)	q_s (kPa)
1	1.1	1.1	5.5	20.2	630.3	650.5	800.0	OK	20.2	117.4	137.5
2	1.1	1.2	5.5	21.0	630.3	651.3	800.0	OK	20.9	117.4	138.3
3	1.2	1.2	5.5	21.8	630.3	652.1	800.0	OK	21.6	117.4	139.0
4	1.2	1.3	5.5	22.6	630.3	652.9	800.0	OK	22.3	117.4	139.7
5	1.3	1.3	5.5	23.4	630.3	653.7	800.0	OK	23.0	117.4	140.4
6	1.3	1.3	5.5	24.2	630.3	654.5	800.0	OK	23.8	117.4	141.1
7	1.3	1.4	5.5	25.0	630.3	655.3	800.0	OK	24.5	117.4	141.9
8	1.4	1.4	5.5	25.8	630.3	656.1	800.0	OK	25.2	117.4	142.6
9	1.4	1.5	5.5	26.6	630.3	656.9	800.0	OK	25.9	117.4	143.3
10	1.5	1.5	5.5	27.4	630.3	657.7	800.0	OK	26.6	117.4	144.0

Notations

$q_{c,0}$	*Initial effective vertical stress in the column*	$q_{s,0}$	*Initial effective vertical stress in the soil*
q_c	*Final effective vertical stress in the column*	q_s	*Final effective vertical stress in the soil*
$\Delta q_{c,max}$	*Limit value as per DTU 13-2 (Fs = 2)*		

Depth correction factor

To take into account the additional lateral constraint due the earth pressure at depth, the settlement reduction ratio is multiplied by a coefficient f_d.

$$\beta_2 = f_d . \beta_1 \quad \text{and} \quad f_d = \frac{1}{1 + \frac{K_{0_c} - \frac{q_{s,0}}{q_{c,0}}}{K_{0_c}} . \frac{q_{c,0}}{\Delta q_c}} \quad \text{with} \quad f_d \geq 1$$

The coefficient f_d is limited by following formula:

$$f_d \leq \frac{M_c}{M_s} . \frac{\Delta q_s}{\Delta q_c}$$

The settlement reduction ratio β_2 is limited by:

$$\beta_{2,max} = 1 + \tau \left(\frac{M_c}{M_s} - 1 \right)$$

Values of the settlement reduction ratio, step 3, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	f_d (-)	$f_{d,max}$ (-)	f_d (-)	β_2 (-)	$\beta_{2,max}$ (-)	β_2 (-)
1	1.1	1.1	1.1	1.6	1.1	1.3	1.5	1.3
2	1.1	1.2	1.1	1.6	1.1	1.3	1.5	1.3
3	1.2	1.2	1.1	1.6	1.1	1.4	1.5	1.4
4	1.2	1.3	1.1	1.6	1.1	1.4	1.5	1.4
5	1.3	1.3	1.1	1.6	1.1	1.4	1.5	1.4
6	1.3	1.3	1.1	1.6	1.1	1.4	1.5	1.4
7	1.3	1.4	1.1	1.6	1.1	1.4	1.5	1.4
8	1.4	1.4	1.1	1.6	1.1	1.4	1.5	1.4
9	1.4	1.5	1.1	1.6	1.1	1.4	1.5	1.4
10	1.5	1.5	1.1	1.6	1.1	1.4	1.5	1.4

Settlement distribution per layer

Over the length of the columns

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)	S_a (m)
1	1.1	1.1	0.001	0.000
2	1.1	1.2	0.001	0.000
3	1.2	1.2	0.001	0.000
4	1.2	1.3	0.001	0.000
5	1.3	1.3	0.001	0.000
6	1.3	1.3	0.001	0.000
7	1.3	1.4	0.001	0.000
8	1.4	1.4	0.001	0.000
9	1.4	1.5	0.001	0.000
10	1.5	1.5	0.001	0.000
		TOTAL	**0.007**	**0.005**

Notations

- S_{na} — *Settlement of soil without soil improvement*
- S_a — *Settlement of soil with soil improvement*

The total settlement in the soil w/o improvement under an uniform load is: **0.7 cm**

The settlement decrease ratio under an uniform load is: **1.4**

The total settlement of the improved soil under an uniform load is: **0.5 cm**

Below the improved soil layers

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)
11	1.5	3.5	0.003
12	3.5	10.0	0.022
		TOTAL	**0.025**

The settlement below the improved soil layers is: **2.5 cm**

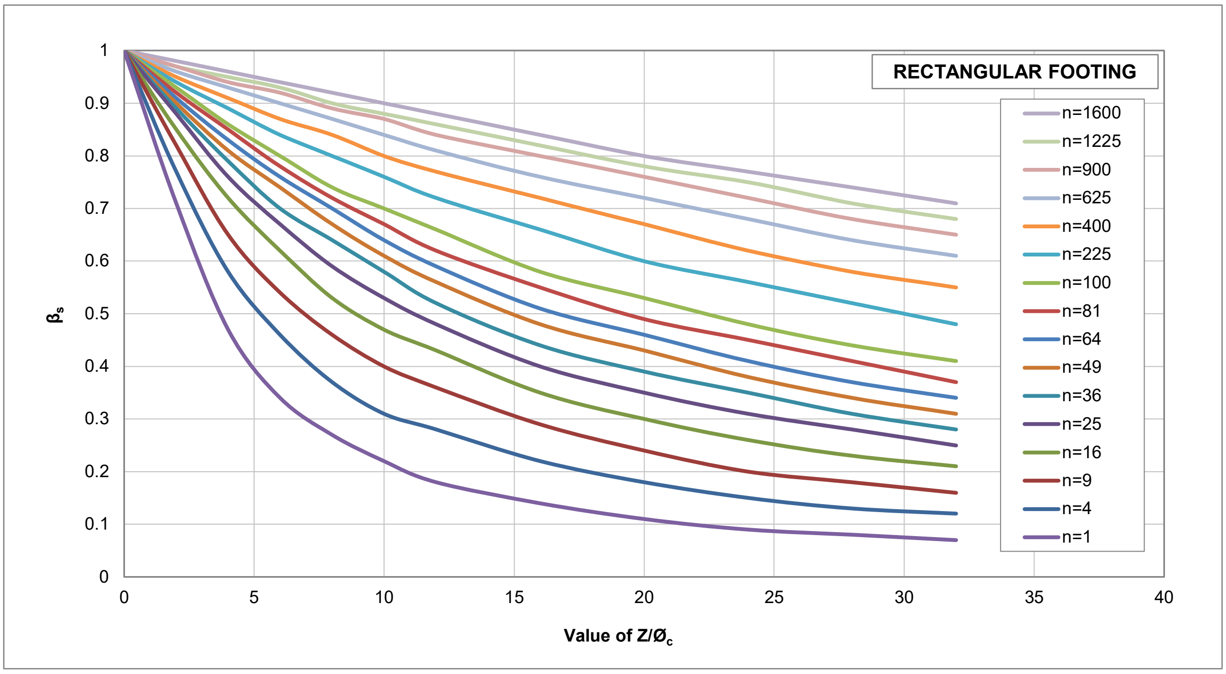
THE TOTAL SETTLEMENT OF THE SOIL UNDER AN UNIFORM LOAD IS **3.0 cm**

LOADING ON THE FOOTING

Settlement distribution

Over the length of the columns

This calculation is made by applying a new settlement reduction factor β_s to the settlement of the soil improved by stone columns.
Priebe has given a diagram of β_s values depending on the depth/diameter ratio $z/Ø_c$ and number of Stone Columns n.



The number of columns below the footing is: 10

The settlement of a layer at a depth Z below the base of the footing is determined as the difference of the settlements calculated between the lower bound Z_{inf} and the upper bound Z_{sup} of the concerned layer, with an average β_s calculated over the thickness of this layer:

$$S_{a,s}(z) = \frac{\Delta q}{M_s \beta_2}\left[(\beta_s)_{inf}.Z_{inf} - (\beta_s)_{sup}.Z_{sup}\right]$$

Layer n°	z sup (m)	z inf (m)	Z sup (m)	Z inf (m)	Z sup /Ø c (-)	Z inf /Ø c (-)	(β s) sup (-)	(β s) inf (-)	S a,s (m)
1	1.1	1.1	0.0	0.0	0.00	0.10	1.00	0.99	0.000
2	1.1	1.2	0.0	0.1	0.10	0.20	0.99	0.98	0.000
3	1.2	1.2	0.1	0.1	0.20	0.30	0.98	0.97	0.000
4	1.2	1.3	0.1	0.2	0.30	0.40	0.97	0.96	0.000
5	1.3	1.3	0.2	0.2	0.40	0.50	0.96	0.96	0.000
6	1.3	1.3	0.2	0.2	0.50	0.60	0.96	0.95	0.000
7	1.3	1.4	0.2	0.3	0.60	0.70	0.95	0.94	0.000
8	1.4	1.4	0.3	0.3	0.70	0.80	0.94	0.93	0.000
9	1.4	1.5	0.3	0.4	0.80	0.90	0.93	0.92	0.000
10	1.5	1.5	0.4	0.4	0.90	1.00	0.92	0.91	0.000
								TOTAL	0.004

The total settlement of the improved soil under the footing is: 0.4 cm

Notations

Z_{sup}	Depth of the top of the soil layer from the foundation base	$(\beta_s)_{sup}$	Settlement reduction factor at the level of z_{sup}
Z_{inf}	Depth of the bottom of the soil layer from the foundation base	$(\beta_s)_{inf}$	Settlement reduction factor at the level of z_{inf}
$S_{a,s}$	Settlement of soil with soil improvement		

Below the improved soil layers

Layer n°	z sup (m)	z inf (m)	S na,s (m)
11	1.5	3.5	0.003
12	3.5	10.0	0.006
		TOTAL	0.009

The settlement below the improved soil layers is: 0.9 cm

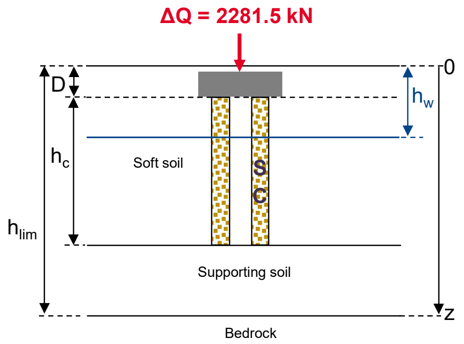
THE TOTAL SETTLEMENT OF THE SOIL BELOW THE FOOTING IS 1.3 cm

Project name: **Poyle pad @150kPa**
3.9m x 3.9m pad (E)

Area of the rectangular footing: 3.90 m x 3.90 m **Footing loaded at** ΔQ = 2,281.5 kN

DESIGN AS PER PRIEBE METHOD

Presentation of the model and main calculation results



Area of the footing =	15.21 m²		
Diameter of the columns =	0.4 m	to	0.4 m
Total settlement =	1.2 cm		
Maximal stress within the columns =	625.3 kPa		

Description of Stone Columns reinforcement

Description of the footing

Type of footing: **Rectangular**

L	3.9 m	*Length of the footing*	d	1.1 m	*Embedment height*
B	3.9 m	*Width of the footing*	$A_{footing}$	15.21 m²	*Area of the footing*

Number of columns under the footing: 8

Description of the stone columns

A	1.90 m²	*Equivalent grid area of the columns*	γ_c	20 kN/m³	*Unit weight of the gravel*
h_c	0.4 m	*Length of the columns*	φ_c	38 °	*Friction angle of the gravel*
E_c	50,000 kPa	*Young's modulus*	Ka_c	0.24	*Coefficient of active earth pressure*
ν_c	0.33	*Poisson's coefficient*	K_{0c}	0.38	*Coefficient of earth pressure at rest*
M_c	75,000 kPa	*Oedometric modulus*			

Description of natural soil surrounding the columns

h_w 1.5 m *Depth of Ground Water Table*

Priebe considers: $K_{0s} = 1$ *with* K_{0s} *: coefficient of earth pressure at rest*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	ν_s (-)	γ_s (kN/m³)	M_s (kPa)	$Ø_c$ (m)	τ (%)	p_l* (kPa)
1	1.1	1.1	6,000	0.33	18	9,000	0.40	6.6%	400
2	1.1	1.2	6,000	0.33	18	9,000	0.40	6.6%	400
3	1.2	1.2	6,000	0.33	18	9,000	0.40	6.6%	400
4	1.2	1.3	6,000	0.33	18	9,000	0.40	6.6%	400
5	1.3	1.3	6,000	0.33	18	9,000	0.40	6.6%	400
6	1.3	1.3	6,000	0.33	18	9,000	0.40	6.6%	400
7	1.3	1.4	6,000	0.33	18	9,000	0.40	6.6%	400
8	1.4	1.4	6,000	0.33	18	9,000	0.40	6.6%	400
9	1.4	1.5	6,000	0.33	18	9,000	0.40	6.6%	400
10	1.5	1.5	6,000	0.33	18	9,000	0.40	6.6%	400

Description of natural soil below the columns

h_{lim} 10.0 m *Limit depth of model*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	ν_s (-)	M_s (kPa)
11	1.5	3.5	60,000	0.33	90,000
12	3.5	10.0	30,000	0.33	45,000

Notations

z_{sup}	*Depth of the top of the soil layer*	M_s	*Oedometric modulus in the layer*
z_{inf}	*Depth of the bottom of the soil layer*	$Ø_c$	*Stone Columns' diameter*
E_s	*Young's modulus in the layer*	τ	*Replacement ratio*
ν_s	*Poisson's coefficient*	p_l*	*Limit pressure in the layer*
γ_s	*Unit weight of the soil layer*		

Loading description at SLS

ΔQ	2,282	kN	*Load applied at the footing base*
Δq	150.0	kPa	*Pressure applied at the footing base*

UNIFORM LOADING

Hypothesis: columns are not compressible

Priebe suggests to use the following settlement reduction ratio, corresponding to an incompressible gravel:

$$\beta = 1 + \tau\left(\frac{f(\nu_s,\tau) + \frac{1}{2}}{f(\nu_s,\tau).K_{a_c}} - 1\right)$$

With:

$$f(\nu_s,\tau) = \frac{1-\nu_s^2}{1-\nu_s-2\nu_s^2}\cdot\frac{(1-2\nu_s)(1-\tau)}{1-2\nu_s+\tau}$$

Values of the settlement reduction ratio, first step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	$f_0(\nu_s,\tau)$ (-)	β_0 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.1	1.1	1.56	1.3	115.3	640.2
2	1.1	1.2	1.56	1.3	115.3	640.2
3	1.2	1.2	1.56	1.3	115.3	640.2
4	1.2	1.3	1.56	1.3	115.3	640.2
5	1.3	1.3	1.56	1.3	115.3	640.2
6	1.3	1.3	1.56	1.3	115.3	640.2
7	1.3	1.4	1.56	1.3	115.3	640.2
8	1.4	1.4	1.56	1.3	115.3	640.2
9	1.4	1.5	1.56	1.3	115.3	640.2
10	1.5	1.5	1.56	1.3	115.3	640.2

Stress in soil and columns is assessed using the following formula:

$$\beta_0 = \frac{\Delta q}{\Delta q_s}$$

$$\Delta q = \tau.\Delta q_c + (1-\tau).\Delta q_s$$

Notations

Δq_s *Additional stress on the soil*

Δq_c *Additional stress in the column*

Column are made of compressible material

To take into account the fact that gravel is compressible, one should modify the replacement ratio value using the compressibility ratio column / soil.

Values of the settlement reduction ratio, second step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	M_c/M_s (-)	$\Delta(1/\tau)$ (-)	$\tau_{corrected}$ (%)	$f(\nu_s,\tau_{corrected})$ (-)	β_1 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.1	1.1	8.3	0.58	6.4%	1.57	1.3	116.4	625.3
2	1.1	1.2	8.3	0.58	6.4%	1.57	1.3	116.4	625.3
3	1.2	1.2	8.3	0.58	6.4%	1.57	1.3	116.4	625.3
4	1.2	1.3	8.3	0.58	6.4%	1.57	1.3	116.4	625.3
5	1.3	1.3	8.3	0.58	6.4%	1.57	1.3	116.4	625.3
6	1.3	1.3	8.3	0.58	6.4%	1.57	1.3	116.4	625.3
7	1.3	1.4	8.3	0.58	6.4%	1.57	1.3	116.4	625.3
8	1.4	1.4	8.3	0.58	6.4%	1.57	1.3	116.4	625.3
9	1.4	1.5	8.3	0.58	6.4%	1.57	1.3	116.4	625.3
10	1.5	1.5	8.3	0.58	6.4%	1.57	1.3	116.4	625.3

Notations

$\Delta(1/\tau)$ *Increase of 1 / τ*

$\tau_{corrected}$ *Modified value of replacement ratio*

Stress distribution per improved layer

The stress distribution ratio is:

$$n = \frac{\Delta q_C}{\Delta q_S} = \frac{f(\nu_s,\tau_{corrected}) + \frac{1}{2}}{f(\nu_s,\tau_{corrected})\cdot K_{a_c}}$$

Layer n°	z_{sup} (m)	z_{inf} (m)	n (-)	$q_{c,0}$ (kPa)	Δq_c (kPa)	q_c (kPa)	$\Delta q_{c,max}$ (kPa)	Checking against bulging failure	$q_{s,0}$ (kPa)	Δq_s (kPa)	q_s (kPa)
1	1.1	1.1	5.5	20.2	625.3	645.5	800.0	OK	20.2	116.4	136.5
2	1.1	1.2	5.5	21.0	625.3	646.3	800.0	OK	20.9	116.4	137.2
3	1.2	1.2	5.5	21.8	625.3	647.1	800.0	OK	21.6	116.4	138.0
4	1.2	1.3	5.5	22.6	625.3	647.9	800.0	OK	22.3	116.4	138.7
5	1.3	1.3	5.5	23.4	625.3	648.7	800.0	OK	23.0	116.4	139.4
6	1.3	1.3	5.5	24.2	625.3	649.5	800.0	OK	23.8	116.4	140.1
7	1.3	1.4	5.5	25.0	625.3	650.3	800.0	OK	24.5	116.4	140.8
8	1.4	1.4	5.5	25.8	625.3	651.1	800.0	OK	25.2	116.4	141.6
9	1.4	1.5	5.5	26.6	625.3	651.9	800.0	OK	25.9	116.4	142.3
10	1.5	1.5	5.5	27.4	625.3	652.7	800.0	OK	26.6	116.4	143.0

Notations

$q_{c,0}$ *Initial effective vertical stress in the column*

q_c *Final effective vertical stress in the column*

$\Delta q_{c,max}$ *Limit value as per DTU 13-2 (Fs = 2)*

$q_{s,0}$ *Initial effective vertical stress in the soil*

q_s *Final effective vertical stress in the soil*

Depth correction factor

To take into account the additional lateral constraint due the earth pressure at depth, the settlement reduction ratio is multiplied by a coefficient f_d.

$$\beta_2 = f_d . \beta_1 \quad \textit{and} \quad f_d = \frac{1}{1 + \frac{K_{0_c} - \frac{q_{s,0}}{q_{c,0}}}{K_{0_c}} . \frac{q_{c,0}}{\Delta q_c}} \quad \textit{with} \quad f_d \geq 1$$

The coefficient f_d is limited by following formula: $f_d \leq \frac{M_c}{M_s} . \frac{\Delta q_s}{\Delta q_c}$

The settlement reduction ratio β_2 is limited by: $\beta_{2,max} = 1 + \tau\left(\frac{M_c}{M_s} - 1\right)$

Values of the settlement reduction ratio, step 3, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	f_d (-)	$f_{d,max}$ (-)	f_d (-)	β_2 (-)	$\beta_{2,max}$ (-)	β_2 (-)
1	1.1	1.1	1.1	1.6	1.1	1.4	1.5	1.4
2	1.1	1.2	1.1	1.6	1.1	1.4	1.5	1.4
3	1.2	1.2	1.1	1.6	1.1	1.4	1.5	1.4
4	1.2	1.3	1.1	1.6	1.1	1.4	1.5	1.4
5	1.3	1.3	1.1	1.6	1.1	1.4	1.5	1.4
6	1.3	1.3	1.1	1.6	1.1	1.4	1.5	1.4
7	1.3	1.4	1.1	1.6	1.1	1.4	1.5	1.4
8	1.4	1.4	1.1	1.6	1.1	1.4	1.5	1.4
9	1.4	1.5	1.1	1.6	1.1	1.4	1.5	1.4
10	1.5	1.5	1.1	1.6	1.1	1.4	1.5	1.4

Settlement distribution per layer

Over the length of the columns

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)	S_a (m)
1	1.1	1.1	0.001	0.000
2	1.1	1.2	0.001	0.000
3	1.2	1.2	0.001	0.000
4	1.2	1.3	0.001	0.000
5	1.3	1.3	0.001	0.000
6	1.3	1.3	0.001	0.000
7	1.3	1.4	0.001	0.000
8	1.4	1.4	0.001	0.000
9	1.4	1.5	0.001	0.000
10	1.5	1.5	0.001	0.000
		TOTAL	**0.007**	**0.005**

Notations

S_{na} *Settlement of soil without soil improvement*

S_a *Settlement of soil with soil improvement*

The total settlement in the soil w/o improvement under an uniform load is: **0.7 cm**

The settlement decrease ratio under an uniform load is: **1.4**

The total settlement of the improved soil under an uniform load is: **0.5 cm**

Below the improved soil layers

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)
11	1.5	3.5	0.003
12	3.5	10.0	0.022
		TOTAL	**0.025**

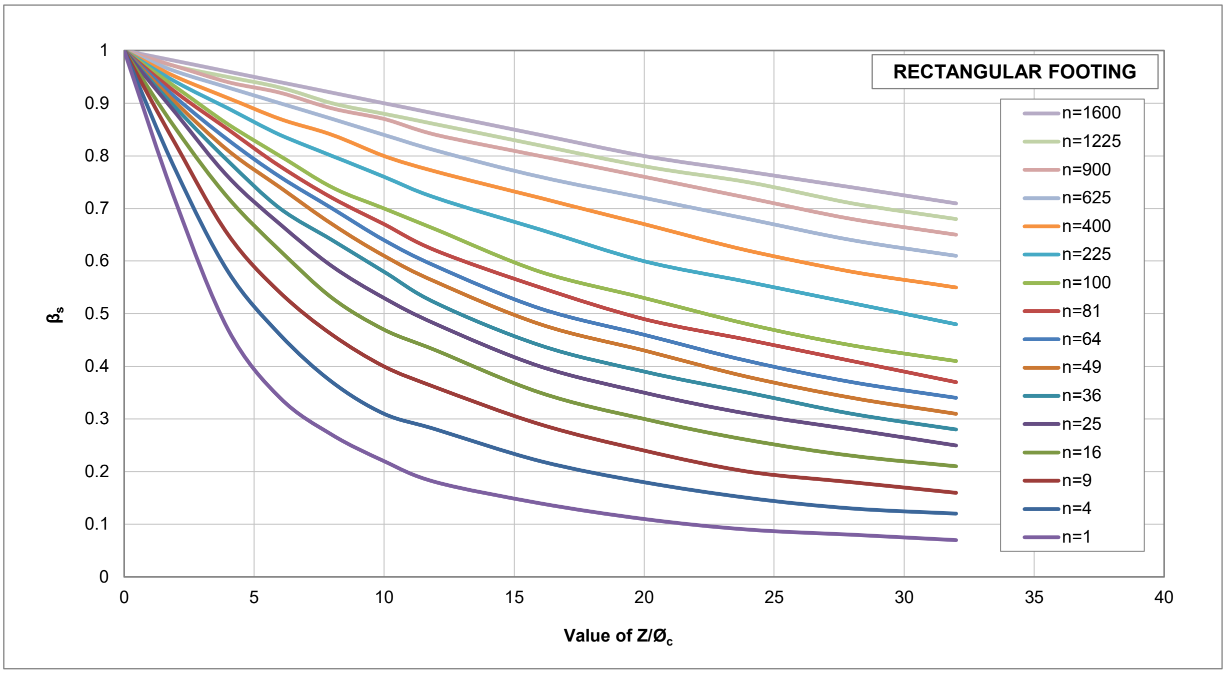
The settlement below the improved soil layers is: **2.5 cm**

THE TOTAL SETTLEMENT OF THE SOIL UNDER AN UNIFORM LOAD IS **3.0 cm**

Settlement distribution

Over the length of the columns

This calculation is made by applying a new settlement reduction factor β_s to the settlement of the soil improved by stone columns.
Priebe has given a diagram of β_s values depending on the depth/diameter ratio $z/Ø_c$ and number of Stone Columns n.



The number of columns below the footing is: 8

The settlement of a layer at a depth Z below the base of the footing is determined as the difference of the settlements calculated between the lower bound Z_{inf} and the upper bound Z_{sup} of the concerned layer, with an average β_s calculated over the thickness of this layer:

$$S_{a,s}(z) = \frac{\Delta q}{M_s \beta_2}\left[(\beta_s)_{inf}.Z_{inf} - (\beta_s)_{sup}.Z_{sup}\right]$$

Layer n°	z sup (m)	z inf (m)	Z sup (m)	Z inf (m)	Z sup /Ø c (-)	Z inf /Ø c (-)	(β s) sup (-)	(β s) inf (-)	S a,s (m)
1	1.1	1.1	0.0	0.0	0.00	0.10	1.00	0.99	0.000
2	1.1	1.2	0.0	0.1	0.10	0.20	0.99	0.98	0.000
3	1.2	1.2	0.1	0.1	0.20	0.30	0.98	0.97	0.000
4	1.2	1.3	0.1	0.2	0.30	0.40	0.97	0.96	0.000
5	1.3	1.3	0.2	0.2	0.40	0.50	0.96	0.95	0.000
6	1.3	1.3	0.2	0.2	0.50	0.60	0.95	0.94	0.000
7	1.3	1.4	0.2	0.3	0.60	0.70	0.94	0.93	0.000
8	1.4	1.4	0.3	0.3	0.70	0.80	0.93	0.92	0.000
9	1.4	1.5	0.3	0.4	0.80	0.90	0.92	0.91	0.000
10	1.5	1.5	0.4	0.4	0.90	1.00	0.91	0.91	0.000
								TOTAL	0.004

The total settlement of the improved soil under the footing is: 0.4 cm

Notations

Z_{sup}	Depth of the top of the soil layer from the foundation base	$(\beta_s)_{sup}$	Settlement reduction factor at the level of z_{sup}
Z_{inf}	Depth of the bottom of the soil layer from the foundation base	$(\beta_s)_{inf}$	Settlement reduction factor at the level of z_{inf}
$S_{a,s}$	Settlement of soil with soil improvement		

Below the improved soil layers

Layer n°	z sup (m)	z inf (m)	S na,s (m)
11	1.5	3.5	0.003
12	3.5	10.0	0.005
		TOTAL	0.008

The settlement below the improved soil layers is: 0.8 cm

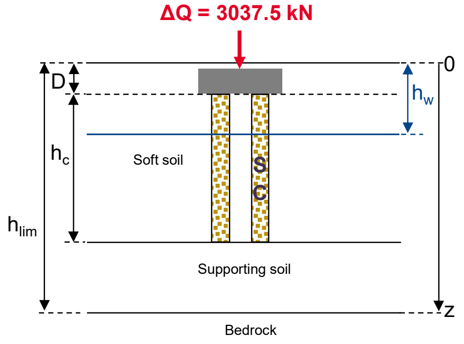
THE TOTAL SETTLEMENT OF THE SOIL BELOW THE FOOTING IS 1.2 cm

Project name: Poyle pad @150kPa
4.5m x 4.5m pad (G)

Area of the rectangular footing: 4.50 m x 4.50 m **Footing loaded at** ΔQ = 3,037.5 kN

DESIGN AS PER PRIEBE METHOD

Presentation of the model and main calculation results



Area of the footing =	20.25 m²
Diameter of the columns =	0.4 m to 0.4 m
Total settlement =	1.3 cm
Maximal stress within the columns =	621.1 kPa

Description of Stone Columns reinforcement

Description of the footing

Type of footing: **Rectangular**

L	4.5 m	*Length of the footing*	d	1.2 m	*Embedment height*
B	4.5 m	*Width of the footing*	$A_{footing}$	20.25 m²	*Area of the footing*

Number of columns under the footing: 11

Description of the stone columns

A	1.84 m²	*Equivalent grid area of the columns*	γ_c	20 kN/m³	*Unit weight of the gravel*
h_c	0.3 m	*Length of the columns*	φ_c	38 °	*Friction angle of the gravel*
E_c	50,000 kPa	*Young's modulus*	Ka_c	0.24	*Coefficient of active earth pressure*
ν_c	0.33	*Poisson's coefficient*	K_{0c}	0.38	*Coefficient of earth pressure at rest*
M_c	75,000 kPa	*Oedometric modulus*			

Description of natural soil surrounding the columns

h_w 1.5 m *Depth of Ground Water Table*

Priebe considers: $K_{0s} = 1$ *with K_{0s} : coefficient of earth pressure at rest*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	ν_s (-)	γ_s (kN/m³)	M_s (kPa)	$Ø_c$ (m)	τ (%)	p_l^* (kPa)
1	1.2	1.2	6,000	0.33	18	9,000	0.40	6.8%	400
2	1.2	1.3	6,000	0.33	18	9,000	0.40	6.8%	400
3	1.3	1.3	6,000	0.33	18	9,000	0.40	6.8%	400
4	1.3	1.3	6,000	0.33	18	9,000	0.40	6.8%	400
5	1.3	1.4	6,000	0.33	18	9,000	0.40	6.8%	400
6	1.4	1.4	6,000	0.33	18	9,000	0.40	6.8%	400
7	1.4	1.4	6,000	0.33	18	9,000	0.40	6.8%	400
8	1.4	1.4	6,000	0.33	18	9,000	0.40	6.8%	400
9	1.4	1.5	6,000	0.33	18	9,000	0.40	6.8%	400
10	1.5	1.5	6,000	0.33	18	9,000	0.40	6.8%	400

Description of natural soil below the columns

h_{lim} 10.0 m *Limit depth of model*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	ν_s (-)	M_s (kPa)
11	1.5	3.5	60,000	0.33	90,000
12	3.5	10.0	30,000	0.33	45,000

Notations

z_{sup}	*Depth of the top of the soil layer*	M_s	*Oedometric modulus in the layer*
z_{inf}	*Depth of the bottom of the soil layer*	$Ø_c$	*Stone Columns' diameter*
E_s	*Young's modulus in the layer*	τ	*Replacement ratio*
ν_s	*Poisson's coefficient*	p_l^*	*Limit pressure in the layer*
γ_s	*Unit weight of the soil layer*		

Loading description at SLS

ΔQ	3,038 kN	*Load applied at the footing base*
Δq	150.0 kPa	*Pressure applied at the footing base*

UNIFORM LOADING

Hypothesis: columns are not compressible

Priebe suggests to use the following settlement reduction ratio, corresponding to an incompressible gravel:

$$\beta = 1 + \tau\left(\frac{f(\nu_s,\tau)+\frac{1}{2}}{f(\nu_s,\tau).K_{a_c}} - 1\right) \qquad \textit{With:} \qquad f(\nu_s,\tau) = \frac{1-\nu_s^2}{1-\nu_s-2\nu_s^2}\cdot\frac{(1-2\nu_s)(1-\tau)}{1-2\nu_s+\tau}$$

Values of the settlement reduction ratio, first step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	$f_0(\nu_s,\tau)$ (-)	β_0 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.2	1.2	1.55	1.3	114.4	636.2
2	1.2	1.3	1.55	1.3	114.4	636.2
3	1.3	1.3	1.55	1.3	114.4	636.2
4	1.3	1.3	1.55	1.3	114.4	636.2
5	1.3	1.4	1.55	1.3	114.4	636.2
6	1.4	1.4	1.55	1.3	114.4	636.2
7	1.4	1.4	1.55	1.3	114.4	636.2
8	1.4	1.4	1.55	1.3	114.4	636.2
9	1.4	1.5	1.55	1.3	114.4	636.2
10	1.5	1.5	1.55	1.3	114.4	636.2

Stress in soil and columns is assessed using the following formula:

$$\beta_0 = \frac{\Delta q}{\Delta q_s}$$

$$\Delta q = \tau.\Delta q_c + (1-\tau).\Delta q_s$$

Notations

Δq_s	*Additional stress on the soil*
Δq_c	*Additional stress in the column*

Column are made of compressible material

To take into account the fact that gravel is compressible, one should modify the replacement ratio value using the compressibility ratio column / soil.

Values of the settlement reduction ratio, second step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	M_c/M_s (-)	$\Delta(1/\tau)$ (-)	$\tau_{corrected}$ (%)	$f(\nu_s,\tau_{corrected})$ (-)	β_1 (-)	Δq_s (kPa)	Δq_c (kPa)
1	1.2	1.2	8.3	0.58	6.6%	1.56	1.3	115.5	621.1
2	1.2	1.3	8.3	0.58	6.6%	1.56	1.3	115.5	621.1
3	1.3	1.3	8.3	0.58	6.6%	1.56	1.3	115.5	621.1
4	1.3	1.3	8.3	0.58	6.6%	1.56	1.3	115.5	621.1
5	1.3	1.4	8.3	0.58	6.6%	1.56	1.3	115.5	621.1
6	1.4	1.4	8.3	0.58	6.6%	1.56	1.3	115.5	621.1
7	1.4	1.4	8.3	0.58	6.6%	1.56	1.3	115.5	621.1
8	1.4	1.4	8.3	0.58	6.6%	1.56	1.3	115.5	621.1
9	1.4	1.5	8.3	0.58	6.6%	1.56	1.3	115.5	621.1
10	1.5	1.5	8.3	0.58	6.6%	1.56	1.3	115.5	621.1

Notations

$\Delta(1/\tau)$	*Increase of 1 / τ*
$\tau_{corrected}$	*Modified value of replacement ratio*

Stress distribution per improved layer

The stress distribution ratio is:

$$n = \frac{\Delta q_C}{\Delta q_s} = \frac{f(\nu_s,\tau_{corrected})+\frac{1}{2}}{f(\nu_s,\tau_{corrected})\cdot K_{a_c}}$$

Layer n°	z_{sup} (m)	z_{inf} (m)	n (-)	$q_{c,0}$ (kPa)	Δq_c (kPa)	q_c (kPa)	$\Delta q_{c,max}$ (kPa)	Checking against bulging failure	$q_{s,0}$ (kPa)	Δq_s (kPa)	q_s (kPa)
1	1.2	1.2	5.6	21.9	621.1	643.0	800.0	OK	21.9	115.5	137.4
2	1.2	1.3	5.6	22.5	621.1	643.6	800.0	OK	22.4	115.5	137.9
3	1.3	1.3	5.6	23.1	621.1	644.2	800.0	OK	23.0	115.5	138.4
4	1.3	1.3	5.6	23.7	621.1	644.8	800.0	OK	23.5	115.5	139.0
5	1.3	1.4	5.6	24.3	621.1	645.4	800.0	OK	24.0	115.5	139.5
6	1.4	1.4	5.6	24.9	621.1	646.0	800.0	OK	24.6	115.5	140.1
7	1.4	1.4	5.6	25.5	621.1	646.6	800.0	OK	25.1	115.5	140.6
8	1.4	1.4	5.6	26.1	621.1	647.2	800.0	OK	25.7	115.5	141.1
9	1.4	1.5	5.6	26.7	621.1	647.8	800.0	OK	26.2	115.5	141.7
10	1.5	1.5	5.6	27.3	621.1	648.4	800.0	OK	26.7	115.5	142.2

Notations

$q_{c,0}$	*Initial effective vertical stress in the column*	$q_{s,0}$	*Initial effective vertical stress in the soil*
q_c	*Final effective vertical stress in the column*	q_s	*Final effective vertical stress in the soil*
$\Delta q_{c,max}$	*Limit value as per DTU 13-2 (Fs = 2)*		

Depth correction factor

To take into account the additional lateral constraint due the earth pressure at depth, the settlement reduction ratio is multiplied by a coefficient f_d.

$$\beta_2 = f_d . \beta_1 \quad \text{and} \quad f_d = \frac{1}{1 + \frac{K_{0_c} - \frac{q_{s,0}}{q_{c,0}}}{K_{0_c}} . \frac{q_{c,0}}{\Delta q_c}} \quad \text{with} \quad f_d \geq 1$$

The coefficient f_d is limited by following formula:

$$f_d \leq \frac{M_c}{M_s} . \frac{\Delta q_s}{\Delta q_c}$$

The settlement reduction ratio β_2 is limited by:

$$\beta_{2,max} = 1 + \tau \left(\frac{M_c}{M_s} - 1 \right)$$

Values of the settlement reduction ratio, step 3, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	f_d (-)	$f_{d,max}$ (-)	f_d (-)	β_2 (-)	$\beta_{2,max}$ (-)	β_2 (-)
1	1.2	1.2	1.1	1.5	1.1	1.4	1.5	1.4
2	1.2	1.3	1.1	1.5	1.1	1.4	1.5	1.4
3	1.3	1.3	1.1	1.5	1.1	1.4	1.5	1.4
4	1.3	1.3	1.1	1.5	1.1	1.4	1.5	1.4
5	1.3	1.4	1.1	1.5	1.1	1.4	1.5	1.4
6	1.4	1.4	1.1	1.5	1.1	1.4	1.5	1.4
7	1.4	1.4	1.1	1.5	1.1	1.4	1.5	1.4
8	1.4	1.4	1.1	1.5	1.1	1.4	1.5	1.4
9	1.4	1.5	1.1	1.5	1.1	1.4	1.5	1.4
10	1.5	1.5	1.1	1.5	1.1	1.4	1.5	1.4

Settlement distribution per layer

Over the length of the columns

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)	S_a (m)
1	1.2	1.2	0.001	0.000
2	1.2	1.3	0.001	0.000
3	1.3	1.3	0.001	0.000
4	1.3	1.3	0.000	0.000
5	1.3	1.4	0.001	0.000
6	1.4	1.4	0.001	0.000
7	1.4	1.4	0.001	0.000
8	1.4	1.4	0.001	0.000
9	1.4	1.5	0.001	0.000
10	1.5	1.5	0.001	0.000
		TOTAL	**0.005**	**0.004**

Notations

S_{na} *Settlement of soil without soil improvement*

S_a *Settlement of soil with soil improvement*

The total settlement in the soil w/o improvement under an uniform load is: 0.5 cm

The settlement decrease ratio under an uniform load is: 1.4

The total settlement of the improved soil under an uniform load is: 0.4 cm

Below the improved soil layers

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)
11	1.5	3.5	0.003
12	3.5	10.0	0.022
		TOTAL	**0.025**

The settlement below the improved soil layers is: 2.5 cm

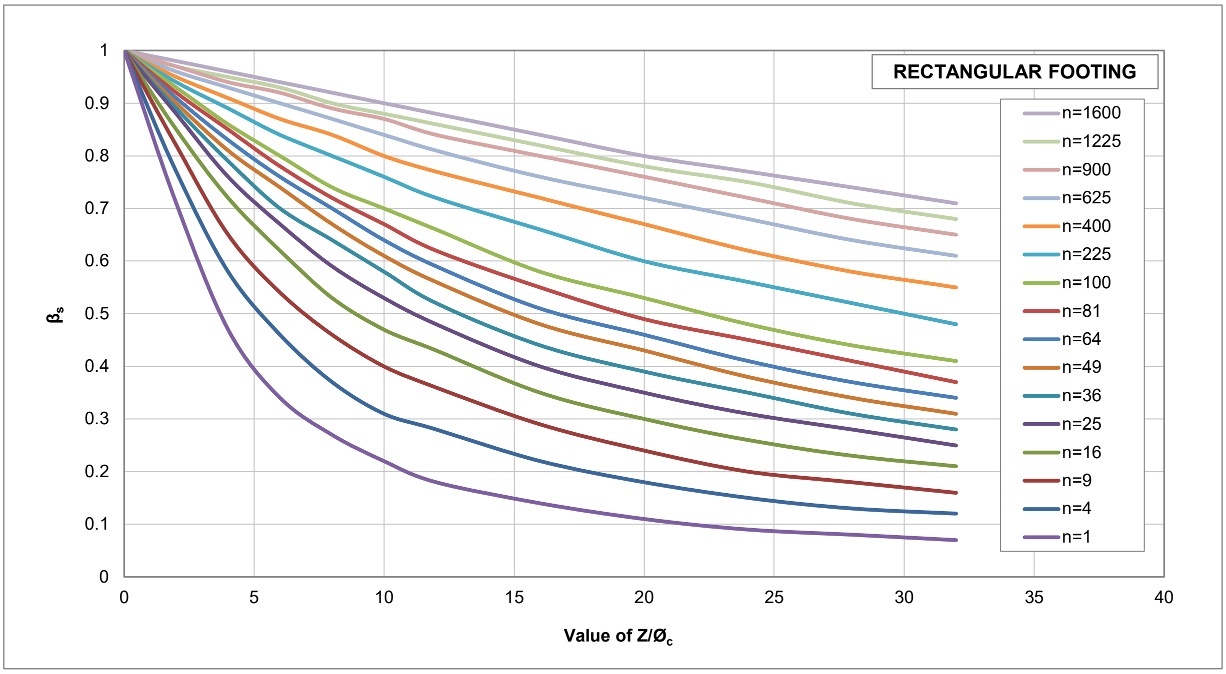
THE TOTAL SETTLEMENT OF THE SOIL UNDER AN UNIFORM LOAD IS 2.9 cm

LOADING ON THE FOOTING

Settlement distribution

Over the length of the columns

This calculation is made by applying a new settlement reduction factor β_s to the settlement of the soil improved by stone columns.
Priebe has given a diagram of β_s values depending on the depth/diameter ratio $z/\text{Ø}_c$ and number of Stone Columns n.



The number of columns below the footing is: **11**

The settlement of a layer at a depth Z below the base of the footing is determined as the difference of the settlements calculated between the lower bound Z_{inf} and the upper bound Z_{sup} of the concerned layer, with an average β_s calculated over the thickness of this layer:

$$S_{a,s}(z) = \frac{\Delta q}{M_s \beta_2}\left[(\beta_s)_{inf}.Z_{inf} - (\beta_s)_{sup}.Z_{sup}\right]$$

Layer n°	z sup (m)	z inf (m)	Z sup (m)	Z inf (m)	Z sup/Ø c (-)	Z inf/Ø c (-)	(β s) sup (-)	(β s) inf (-)	S a,s (m)
1	1.2	1.2	0.0	0.0	0.00	0.08	1.00	0.99	0.000
2	1.2	1.3	0.0	0.1	0.08	0.15	0.99	0.99	0.000
3	1.3	1.3	0.1	0.1	0.15	0.23	0.99	0.98	0.000
4	1.3	1.3	0.1	0.1	0.23	0.30	0.98	0.97	0.000
5	1.3	1.4	0.1	0.2	0.30	0.38	0.97	0.97	0.000
6	1.4	1.4	0.2	0.2	0.38	0.45	0.97	0.96	0.000
7	1.4	1.4	0.2	0.2	0.45	0.53	0.96	0.96	0.000
8	1.4	1.4	0.2	0.2	0.53	0.60	0.96	0.95	0.000
9	1.4	1.5	0.2	0.3	0.60	0.68	0.95	0.94	0.000
10	1.5	1.5	0.3	0.3	0.68	0.75	0.94	0.94	0.000
								TOTAL	**0.003**

The total settlement of the improved soil under the footing is: **0.3 cm**

Notations

Z_{sup}	*Depth of the top of the soil layer from the foundation base*	$(\beta_s)_{sup}$	*Settlement reduction factor at the level of z_{sup}*
Z_{inf}	*Depth of the bottom of the soil layer from the foundation base*	$(\beta_s)_{inf}$	*Settlement reduction factor at the level of z_{inf}*
$S_{a,s}$	*Settlement of soil with soil improvement*		

Below the improved soil layers

Layer n°	z sup (m)	z inf (m)	S na,s (m)
11	1.5	3.5	0.003
12	3.5	10.0	0.006
		TOTAL	**0.009**

The settlement below the improved soil layers is: **0.9 cm**

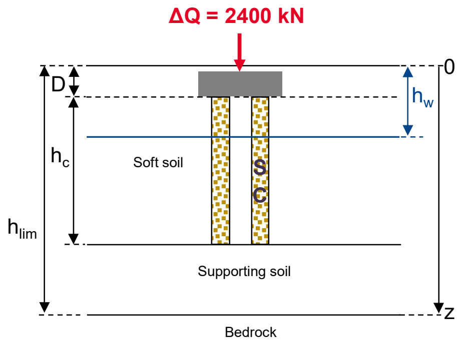
THE TOTAL SETTLEMENT OF THE SOIL BELOW THE FOOTING IS **1.3 cm**

Project name: Poyle pad @150kPa
4.4m x 4.4m pad (C)

Area of the rectangular footing: 4.00 m x 4.00 m **Footing loaded at** ΔQ = 2,400.0 kN

DESIGN AS PER PRIEBE METHOD

Presentation of the model and main calculation results



Area of the footing = 16 m²

Diameter of the columns = 0.4 m to 0.4 m

Total settlement = 1.2 cm

Maximal stress within the columns = 631.8 kPa

Description of Stone Columns reinforcement

Description of the footing

Type of footing: **Rectangular**

L	4 m	*Length of the footing*	d	1.2 m	*Embedment height*
B	4 m	*Width of the footing*	$A_{footing}$	16 m²	*Area of the footing*

Number of columns under the footing: 8

Description of the stone columns

A	2.00 m²	*Equivalent grid area of the columns*	γ_c	20 kN/m³	*Unit weight of the gravel*
h_c	0.3 m	*Length of the columns*	φ_c	38 °	*Friction angle of the gravel*
E_c	50,000 kPa	*Young's modulus*	Ka_c	0.24	*Coefficient of active earth pressure*
ν_c	0.33	*Poisson's coefficient*	K_{0c}	0.38	*Coefficient of earth pressure at rest*
M_c	75,000 kPa	*Oedometric modulus*			

Description of natural soil surrounding the columns

h_w 1.5 m *Depth of Ground Water Table*

Priebe considers: $K_{0s} = 1$ *with K_{0s} : coefficient of earth pressure at rest*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	ν_s (-)	γ_s (kN/m³)	M_s (kPa)	$Ø_c$ (m)	τ (%)	p_l* (kPa)
1	1.2	1.2	6,000	0.33	18	9,000	0.40	6.3%	400
2	1.2	1.3	6,000	0.33	18	9,000	0.40	6.3%	400
3	1.3	1.3	6,000	0.33	18	9,000	0.40	6.3%	400
4	1.3	1.3	6,000	0.33	18	9,000	0.40	6.3%	400
5	1.3	1.4	6,000	0.33	18	9,000	0.40	6.3%	400
6	1.4	1.4	6,000	0.33	18	9,000	0.40	6.3%	400
7	1.4	1.4	6,000	0.33	18	9,000	0.40	6.3%	400
8	1.4	1.4	6,000	0.33	18	9,000	0.40	6.3%	400
9	1.4	1.5	6,000	0.33	18	9,000	0.40	6.3%	400
10	1.5	1.5	6,000	0.33	18	9,000	0.40	6.3%	400

Description of natural soil below the columns

h_{lim} 10.0 m *Limit depth of model*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	ν_s (-)	M_s (kPa)
11	1.5	3.5	60,000	0.33	90,000
12	3.5	10.0	30,000	0.33	45,000

Notations

z_{sup}	*Depth of the top of the soil layer*	M_s	*Oedometric modulus in the layer*
z_{inf}	*Depth of the bottom of the soil layer*	$Ø_c$	*Stone Columns' diameter*
E_s	*Young's modulus in the layer*	τ	*Replacement ratio*
ν_s	*Poisson's coefficient*	p_l*	*Limit pressure in the layer*
γ_s	*Unit weight of the soil layer*		

Loading description at SLS

ΔQ	2,400 kN	*Load applied at the footing base*
Δq	150.0 kPa	*Pressure applied at the footing base*

UNIFORM LOADING

Hypothesis: columns are not compressible

Priebe suggests to use the following settlement reduction ratio, corresponding to an incompressible gravel:

$$\beta = 1 + \tau\left(\frac{f(\nu_s,\tau) + \frac{1}{2}}{f(\nu_s,\tau).K_{a_c}} - 1\right)$$

With:

$$f(\nu_s,\tau) = \frac{1-\nu_s^2}{1-\nu_s-2\nu_s^2}\cdot\frac{(1-2\nu_s)(1-\tau)}{1-2\nu_s+\tau}$$

Values of the settlement reduction ratio, first step, are:

Layer n°	*z sup* (m)	*z inf* (m)	*f 0 (v s ,τ)* (-)	*β 0* (-)	*Δq s* (kPa)	*Δq c* (kPa)
1	1.2	1.2	1.58	1.3	116.7	646.3
2	1.2	1.3	1.58	1.3	116.7	646.3
3	1.3	1.3	1.58	1.3	116.7	646.3
4	1.3	1.3	1.58	1.3	116.7	646.3
5	1.3	1.4	1.58	1.3	116.7	646.3
6	1.4	1.4	1.58	1.3	116.7	646.3
7	1.4	1.4	1.58	1.3	116.7	646.3
8	1.4	1.4	1.58	1.3	116.7	646.3
9	1.4	1.5	1.58	1.3	116.7	646.3
10	1.5	1.5	1.58	1.3	116.7	646.3

Stress in soil and columns is assessed using the following formula:

$$\beta_0 = \frac{\Delta q}{\Delta q_s}$$

$$\Delta q = \tau.\Delta q_c + (1-\tau).\Delta q_s$$

Notations

Δq_s	*Additional stress on the soil*
Δq_c	*Additional stress in the column*

Column are made of compressible material

To take into account the fact that gravel is compressible, one should modify the replacement ratio value using the compressibility ratio column / soil.

Values of the settlement reduction ratio, second step, are:

Layer n°	*z sup* (m)	*z inf* (m)	*M c /M s* (-)	*Δ(1/τ)* (-)	*τ corrected* (%)	*f(v s ,τ corrected)* (-)	*β 1* (-)	*Δq s* (kPa)	*Δq c* (kPa)
1	1.2	1.2	8.3	0.58	6.1%	1.59	1.3	117.7	631.8
2	1.2	1.3	8.3	0.58	6.1%	1.59	1.3	117.7	631.8
3	1.3	1.3	8.3	0.58	6.1%	1.59	1.3	117.7	631.8
4	1.3	1.3	8.3	0.58	6.1%	1.59	1.3	117.7	631.8
5	1.3	1.4	8.3	0.58	6.1%	1.59	1.3	117.7	631.8
6	1.4	1.4	8.3	0.58	6.1%	1.59	1.3	117.7	631.8
7	1.4	1.4	8.3	0.58	6.1%	1.59	1.3	117.7	631.8
8	1.4	1.4	8.3	0.58	6.1%	1.59	1.3	117.7	631.8
9	1.4	1.5	8.3	0.58	6.1%	1.59	1.3	117.7	631.8
10	1.5	1.5	8.3	0.58	6.1%	1.59	1.3	117.7	631.8

Notations

$\Delta(1/\tau)$	*Increase of 1 / τ*
$\tau_{corrected}$	*Modified value of replacement ratio*

Stress distribution per improved layer

The stress distribution ratio is:

$$n = \frac{\Delta q_C}{\Delta q_S} = \frac{f(\nu_s,\tau_{corrected}) + \frac{1}{2}}{f(\nu_s,\tau_{corrected})\cdot K_{a_c}}$$

Layer n°	*z sup* (m)	*z inf* (m)	*n* (-)	*q c,0* (kPa)	*Δq c* (kPa)	*q c* (kPa)	*Δq c,max* (kPa)	Checking against bulging failure	*q s,0* (kPa)	*Δq s* (kPa)	*q s* (kPa)
1	1.2	1.2	5.5	21.9	631.8	653.7	800.0	OK	21.9	117.7	139.6
2	1.2	1.3	5.5	22.5	631.8	654.3	800.0	OK	22.4	117.7	140.1
3	1.3	1.3	5.5	23.1	631.8	654.9	800.0	OK	23.0	117.7	140.6
4	1.3	1.3	5.5	23.7	631.8	655.5	800.0	OK	23.5	117.7	141.2
5	1.3	1.4	5.5	24.3	631.8	656.1	800.0	OK	24.0	117.7	141.7
6	1.4	1.4	5.5	24.9	631.8	656.7	800.0	OK	24.6	117.7	142.3
7	1.4	1.4	5.5	25.5	631.8	657.3	800.0	OK	25.1	117.7	142.8
8	1.4	1.4	5.5	26.1	631.8	657.9	800.0	OK	25.7	117.7	143.3
9	1.4	1.5	5.5	26.7	631.8	658.5	800.0	OK	26.2	117.7	143.9
10	1.5	1.5	5.5	27.3	631.8	659.1	800.0	OK	26.7	117.7	144.4

Notations

$q_{c,0}$	*Initial effective vertical stress in the column*
q_c	*Final effective vertical stress in the column*
$\Delta q_{c,max}$	*Limit value as per DTU 13-2 (Fs = 2)*
$q_{s,0}$	*Initial effective vertical stress in the soil*
q_s	*Final effective vertical stress in the soil*

Depth correction factor

To take into account the additional lateral constraint due the earth pressure at depth, the settlement reduction ratio is multiplied by a coefficient f_d.

$$\beta_2 = f_d . \beta_1 \quad \textit{and} \quad f_d = \frac{1}{1 + \frac{K_{0_c} - \frac{q_{s,0}}{q_{c,0}}}{K_{0_c}} . \frac{q_{c,0}}{\Delta q_c}} \quad \textit{with} \quad f_d \geq 1$$

The coefficient f_d is limited by following formula:

$$f_d \leq \frac{M_c}{M_s} . \frac{\Delta q_s}{\Delta q_c}$$

The settlement reduction ratio β_2 is limited by:

$$\beta_{2,max} = 1 + \tau \left(\frac{M_c}{M_s} - 1 \right)$$

Values of the settlement reduction ratio, step 3, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	f_d (-)	$f_{d,max}$ (-)	f_d (-)	β_2 (-)	$\beta_{2,max}$ (-)	β_2 (-)
1	1.2	1.2	1.1	1.6	1.1	1.3	1.5	1.3
2	1.2	1.3	1.1	1.6	1.1	1.4	1.5	1.4
3	1.3	1.3	1.1	1.6	1.1	1.4	1.5	1.4
4	1.3	1.3	1.1	1.6	1.1	1.4	1.5	1.4
5	1.3	1.4	1.1	1.6	1.1	1.4	1.5	1.4
6	1.4	1.4	1.1	1.6	1.1	1.4	1.5	1.4
7	1.4	1.4	1.1	1.6	1.1	1.4	1.5	1.4
8	1.4	1.4	1.1	1.6	1.1	1.4	1.5	1.4
9	1.4	1.5	1.1	1.6	1.1	1.4	1.5	1.4
10	1.5	1.5	1.1	1.6	1.1	1.4	1.5	1.4

Settlement distribution per layer

Over the length of the columns

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)	S_a (m)
1	1.2	1.2	0.001	0.000
2	1.2	1.3	0.001	0.000
3	1.3	1.3	0.001	0.000
4	1.3	1.3	0.000	0.000
5	1.3	1.4	0.001	0.000
6	1.4	1.4	0.001	0.000
7	1.4	1.4	0.001	0.000
8	1.4	1.4	0.001	0.000
9	1.4	1.5	0.001	0.000
10	1.5	1.5	0.001	0.000
		TOTAL	**0.005**	**0.004**

Notations

S_{na}	*Settlement of soil without soil improvement*
S_a	*Settlement of soil with soil improvement*

The total settlement in the soil w/o improvement under an uniform load is: **0.5 cm**

The settlement decrease ratio under an uniform load is: **1.4**

The total settlement of the improved soil under an uniform load is: **0.4 cm**

Below the improved soil layers

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)
11	1.5	3.5	0.003
12	3.5	10.0	0.022
		TOTAL	**0.025**

The settlement below the improved soil layers is: **2.5 cm**

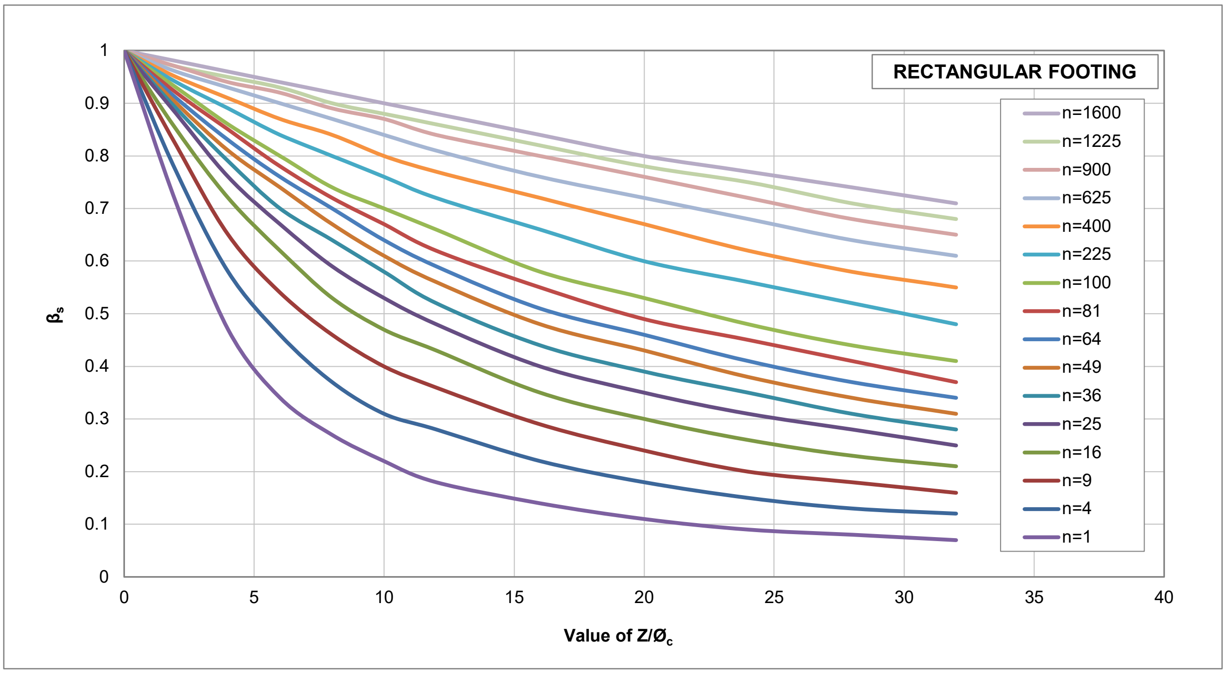
THE TOTAL SETTLEMENT OF THE SOIL UNDER AN UNIFORM LOAD IS **2.9 cm**

LOADING ON THE FOOTING

Settlement distribution

Over the length of the columns

This calculation is made by applying a new settlement reduction factor β_s to the settlement of the soil improved by stone columns.
Priebe has given a diagram of β_s values depending on the depth/diameter ratio $z/Ø_c$ and number of Stone Columns n.



The number of columns below the footing is: 8

The settlement of a layer at a depth Z below the base of the footing is determined as the difference of the settlements calculated between the lower bound Z_{inf} and the upper bound Z_{sup} of the concerned layer, with an average β_s calculated over the thickness of this layer:

$$S_{a,s}(z) = \frac{\Delta q}{M_s \beta_2}\left[(\beta_s)_{inf}.Z_{inf} - (\beta_s)_{sup}.Z_{sup}\right]$$

Layer n°	z sup (m)	z inf (m)	Z sup (m)	Z inf (m)	Z sup/Ø c (-)	Z inf/Ø c (-)	(β s) sup (-)	(β s) inf (-)	S a,s (m)
1	1.2	1.2	0.0	0.0	0.00	0.08	1.00	0.99	0.000
2	1.2	1.3	0.0	0.1	0.08	0.15	0.99	0.99	0.000
3	1.3	1.3	0.1	0.1	0.15	0.23	0.99	0.98	0.000
4	1.3	1.3	0.1	0.1	0.23	0.30	0.98	0.97	0.000
5	1.3	1.4	0.1	0.2	0.30	0.38	0.97	0.96	0.000
6	1.4	1.4	0.2	0.2	0.38	0.45	0.96	0.96	0.000
7	1.4	1.4	0.2	0.2	0.45	0.53	0.96	0.95	0.000
8	1.4	1.4	0.2	0.2	0.53	0.60	0.95	0.94	0.000
9	1.4	1.5	0.2	0.3	0.60	0.68	0.94	0.94	0.000
10	1.5	1.5	0.3	0.3	0.68	0.75	0.94	0.93	0.000
								TOTAL	0.003

The total settlement of the improved soil under the footing is: 0.3 cm

Notations

Z_{sup}	Depth of the top of the soil layer from the foundation base	$(\beta_s)_{sup}$	Settlement reduction factor at the level of z_{sup}
Z_{inf}	Depth of the bottom of the soil layer from the foundation base	$(\beta_s)_{inf}$	Settlement reduction factor at the level of z_{inf}
$S_{a,s}$	Settlement of soil with soil improvement		

Below the improved soil layers

Layer n°	z sup (m)	z inf (m)	S na,s (m)
11	1.5	3.5	0.003
12	3.5	10.0	0.005
		TOTAL	0.008

The settlement below the improved soil layers is: 0.8 cm

THE TOTAL SETTLEMENT OF THE SOIL BELOW THE FOOTING IS 1.2 cm

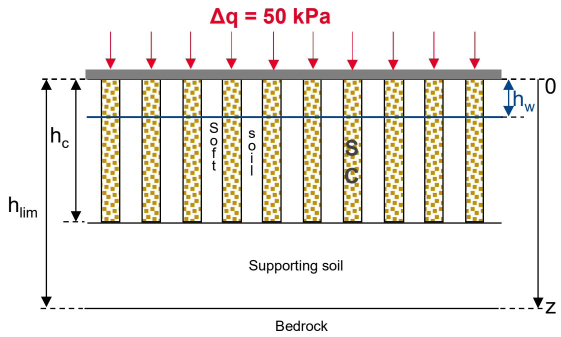
APPENDIX 2: DETAILED CALCULATIONS BENEATH THE SLABS

Project name: Poyle
50 kPa grid 3 x 3

Stone Columns' grid area: 9 m² **Load:** Δq = 50.0 kPa

DESIGN AS PER PRIEBE METHOD

Presentation of the model and main calculation results



Area of the SC grid =	9 m²		
Diameter of the columns =	0.4 m	to	0.4 m
Total settlement =	1.6 cm		
Maximal stress within the columns =			249.8 kPa

Description of Stone Columns

h_c 1.5 m *Column's depth*

Grid dimensions

A	9 m²	*Grid's area*
D	3.00 m	*Distance Centre to Centre - square grid*

Description of the material in the columns

E_c	50,000 kPa	*Young's modulus*	φ_c	38 °	*Friction angle*
ν_c	0.33	*Poisson's coefficient*	Ka_c	0.24	*Coefficient of active earth pressure*
M_c	75,000 kPa	*Oedometric modulus*	K_{0c}	0.38	*Coefficient of earth pressure at rest*
γ_c	20 kN/m³	*Unit weight of compacted gravel*			

Description of natural soil surrounding the columns

h_w 1.5 m *Depth of Ground Water Table*

Priebe considers: $K_{0s} = 1$ *with* K_{0s} *: coefficient of earth pressure at rest*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	ν_s (-)	γ_s (kN/m³)	M_s (kPa)	$Ø_c$ (m)	A_c (m²)	τ (%)	p_l* (kPa)
1	0.0	0.2	6,000	0.33	18	8,890	0.40	0.13	1.4%	500
2	0.2	0.3	6,000	0.33	18	8,890	0.40	0.13	1.4%	500
3	0.3	0.5	6,000	0.33	18	8,890	0.40	0.13	1.4%	500
4	0.5	0.6	6,000	0.33	18	8,890	0.40	0.13	1.4%	500
5	0.6	0.8	6,000	0.33	18	8,890	0.40	0.13	1.4%	500
6	0.8	0.9	6,000	0.33	18	8,890	0.40	0.13	1.4%	400
7	0.9	1.1	6,000	0.33	18	8,890	0.40	0.13	1.4%	400
8	1.1	1.2	6,000	0.33	18	8,890	0.40	0.13	1.4%	400
9	1.2	1.4	6,000	0.33	18	8,890	0.40	0.13	1.4%	400
10	1.4	1.5	6,000	0.33	18	8,890	0.40	0.13	1.4%	400

Description of natural soil below the columns

h_{lim} 10.0 m *Limit depth of model*

Layer n°	z_{sup} (m)	z_{inf} (m)	E_s (kPa)	ν_s (-)	M_s (kPa)
11	1.5	3.5	60,000	0.33	88,899
12	3.5	10.0	30,000	0.33	44,449

Notations

z_{sup}	*Depth of the top of the layer*	$Ø_c$	*Column's diameter*
z_{inf}	*depth of the bottom of the layer*	A_c	*Column's area*
E_s	*Young's modulus in the layer*	τ	*Replacement ratio*
ν_s	*Poisson's coefficient*	p_l*	*Limit pressure in the layer*
γ_s	*Unit weight of the soil*		
M_s	*Oedometric modulus in the layer*		

Loading description

Δq 50 kPa *Uniform spread load*

Hypothesis: columns are not compressible

Priebe suggests to use the following settlement reduction ratio, corresponding to an incompressible gravel:

$$\beta = 1 + \tau.\left(\frac{f(v_s,\tau) + \frac{1}{2}}{f(v_s,\tau)\cdot K_{a_c}} - 1\right)$$

With :

$$f(v_s,\tau) = \frac{1 - {v_s}^2}{1 - v_s - 2.{v_s}^2}\cdot\frac{(1 - 2.v_s)\cdot(1-\tau)}{1 - 2.v_s + \tau}$$

Values of the settlement reduction ratio, first step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	$f_0(v_s,\tau)$ (-)	β_0 (-)	Δq_s (kPa)	Δq_c (kPa)
1	0.0	0.2	1.87	1.1	47.1	251.3
2	0.2	0.3	1.87	1.1	47.1	251.3
3	0.3	0.5	1.87	1.1	47.1	251.3
4	0.5	0.6	1.87	1.1	47.1	251.3
5	0.6	0.8	1.87	1.1	47.1	251.3
6	0.8	0.9	1.87	1.1	47.1	251.3
7	0.9	1.1	1.87	1.1	47.1	251.3
8	1.1	1.2	1.87	1.1	47.1	251.3
9	1.2	1.4	1.87	1.1	47.1	251.3
10	1.4	1.5	1.87	1.1	47.1	251.3

Stress in soil and columns is assessed using the following formula:

$$\beta_0 = \frac{\Delta q}{\Delta q_s}$$

$$\Delta q = \tau.\Delta q_C + (1-\tau).\Delta q_s$$

Notations

Δq_s *Additional stress on the soil*

Δq_c *Additional stress in the column*

Column are made of compressible material

To take into account the fact that gravel is compressible, one should modify the replacement ratio value using the compressibility ratio column / soil.

Values of the settlement reduction ratio, second step, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	M_c/M_s (-)	$\Delta(1/\tau)$ (-)	$\tau_{corrected}$ (%)	$f(v_s,\tau_{corrected})$ (-)	β_1 (-)	Δq_s (kPa)	Δq_c (kPa)
1	0.0	0.2	8.4	0.57	1.4%	1.87	1.1	47.2	249.8
2	0.2	0.3	8.4	0.57	1.4%	1.87	1.1	47.2	249.8
3	0.3	0.5	8.4	0.57	1.4%	1.87	1.1	47.2	249.8
4	0.5	0.6	8.4	0.57	1.4%	1.87	1.1	47.2	249.8
5	0.6	0.8	8.4	0.57	1.4%	1.87	1.1	47.2	249.8
6	0.8	0.9	8.4	0.57	1.4%	1.87	1.1	47.2	249.8
7	0.9	1.1	8.4	0.57	1.4%	1.87	1.1	47.2	249.8
8	1.1	1.2	8.4	0.57	1.4%	1.87	1.1	47.2	249.8
9	1.2	1.4	8.4	0.57	1.4%	1.87	1.1	47.2	249.8
10	1.4	1.5	8.4	0.57	1.4%	1.87	1.1	47.2	249.8

Notations

$\Delta(1/\tau)$ *Increase of 1 / τ*

$\tau_{corrected}$ *Modified value of replacement ratio*

Stress distribution per improved layer

The stress distribution ratio is:

$$n = \frac{\Delta q_C}{\Delta q_s} = \frac{f(v_s,\tau_{corrected}) + \frac{1}{2}}{f(v_s,\tau_{corrected})\cdot K_{a_c}}$$

Layer n°	z_{sup} (m)	z_{inf} (m)	n (-)	$q_{c,0}$ (kPa)	Δq_c (kPa)	q_c (kPa)	$\Delta q_{c,max}$ (kPa)	Checking against bulging failure	$q_{s,0}$ (kPa)	Δq_s (kPa)	q_s (kPa)
1	0.0	0.2	5.3	1.6	249.8	251.4	800.0	OK	1.4	47.2	48.6
2	0.2	0.3	5.3	4.8	249.8	254.6	800.0	OK	4.3	47.2	51.5
3	0.3	0.5	5.3	8.0	249.8	257.8	800.0	OK	7.2	47.2	54.4
4	0.5	0.6	5.3	11.2	249.8	261.0	800.0	OK	10.1	47.2	57.3
5	0.6	0.8	5.3	14.4	249.8	264.2	800.0	OK	13.0	47.2	60.1
6	0.8	0.9	5.3	17.4	249.8	267.2	800.0	OK	15.7	47.2	62.8
7	0.9	1.1	5.3	20.2	249.8	270.0	800.0	OK	18.2	47.2	65.4
8	1.1	1.2	5.3	23.0	249.8	272.8	800.0	OK	20.7	47.2	67.9
9	1.2	1.4	5.3	25.8	249.8	275.6	800.0	OK	23.2	47.2	70.4
10	1.4	1.5	5.3	28.6	249.8	278.4	800.0	OK	25.7	47.2	72.9

Notations

$q_{c,0}$ *Initial effective vertical stress in the column*

q_c *Final effective vertical stress in the column*

$\Delta q_{c,max}$ *Limit value as per DTU 13-2 (Fs = 2)*

$q_{s,0}$ *Initial effective vertical stress in the soil*

q_s *Final effective vertical stress in the soil*

Depth factor

To take into account the additional lateral constraint due the earth pressure at depth, the settlement reduction ratio is multiplied by a coefficient f_d.

$$\beta_2 = f_d \cdot \beta_1$$

and

$$f_d = \frac{1}{1 + \dfrac{K_{0c} - \dfrac{q_{s,0}}{q_{c,0}}}{K_{0c}} \cdot \dfrac{q_{c,0}}{\Delta q_C}}$$

with $f_d \geq 1$

The coefficient f_d is limited by following formula:

$$f_d \leq \frac{M_c}{M_s} \cdot \frac{\Delta q_s}{\Delta q_c}$$

The settlement reduction ratio β_2 is limited by:

$$\beta_{2,max} = 1 + \tau . \left(\frac{M_c}{M_s} - 1\right)$$

Values of the settlement reduction ratio, step 3, are:

Layer n°	z_{sup} (m)	z_{inf} (m)	f_d (-)	$f_{d,max}$ (-)	f_d (-)	β_2 (-)	$\beta_{2,max}$ (-)	β_2 (-)
1	0.0	0.2	1.0	1.6	1.0	1.1	1.1	1.1
2	0.2	0.3	1.0	1.6	1.0	1.1	1.1	1.1
3	0.3	0.5	1.0	1.6	1.0	1.1	1.1	1.1
4	0.5	0.6	1.1	1.6	1.1	1.1	1.1	1.1
5	0.6	0.8	1.1	1.6	1.1	1.1	1.1	1.1
6	0.8	0.9	1.1	1.6	1.1	1.2	1.1	1.1
7	0.9	1.1	1.1	1.6	1.1	1.2	1.1	1.1
8	1.1	1.2	1.1	1.6	1.1	1.2	1.1	1.1
9	1.2	1.4	1.2	1.6	1.2	1.2	1.1	1.1
10	1.4	1.5	1.2	1.6	1.2	1.3	1.1	1.1

Settlement distribution per layer

Over the length of the columns

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)	S_a (m)
1	0.0	0.2	0.001	0.001
2	0.2	0.3	0.001	0.001
3	0.3	0.5	0.001	0.001
4	0.5	0.6	0.001	0.001
5	0.6	0.8	0.001	0.001
6	0.8	0.9	0.001	0.001
7	0.9	1.1	0.001	0.001
8	1.1	1.2	0.001	0.001
9	1.2	1.4	0.001	0.001
10	1.4	1.5	0.001	0.001
		TOTAL	**0.008**	**0.008**

Notations

S_{na} *Settlement of soil without soil improvement*

S_a *Settlement of soil with soil improvement*

Total settlement in the soil w/o improvement: **0.8 cm**

The settlement decrease ratio is: **1.1**

Total settlement of the improved soil: **0.8 cm**

Below the improved soil layers

Layer n°	z_{sup} (m)	z_{inf} (m)	S_{na} (m)
11	1.5	3.5	0.001
12	3.5	10.0	0.007
		TOTAL	**0.008**

Settlement below the improved soil layers: **0.8 cm**

TOTAL SETTLEMENT OF THE SOIL **1.6 cm**

VIBRO MENARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
	Daily Record Sheet – Vibro Stone Columns	Issue Date: 08/01/18
		Page: 1 of 1

Sheet No: 1 of 1
Date: 17/04/2024
Rig No: ABI TM13

Contract Name: POYLE
Day: WEDS
Operator: W. WALKER

Contract Number: 6726
Week Ending: 19/4/24
Supervisor: L-CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	421	1.2			
2	403	1.2			
3	422	1.2			
4	404	1.2			
5	300	1.2			
6	301	1.2			
7	302	1.2			
8	317	1.2			
9	318	1.2			
10	319	1.2			
11	322	1.2			
12	348	1.2			
13	349	1.2			
14	350	1.2			
15	425	1.2			
16	405	1.2			
17	425	1.2			
18	313	1.2			
19	306	1.2			
20	314	12			
21	334	1.2			
22	343	1.2			
23	351	1.2			
24	344	1.2			
25	282	1.2			
26	283	1.2			
27	277	1.2			
28	273	1.2			
29	274	1.2			
30					
Totals	29	34.8			
Running Total	1068	1092.8			

Pre - Auger used on site for above date: YES / NO (NO circled)

Chargeable Standing Time:

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER **Signature:** [signature]

Client Name: Matt Coffey **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO MENARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
Daily Record Sheet – Vibro Stone Columns		Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	1 of 1	Contract Name:	POYLE	Contract Number:	6726
Date:	17/04/2024	Day:	WEDS	Week Ending:	19/4/24
Rig No:	ABI TM13	Operator:	W. WALKER	Supervisor:	L-CARTR

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	421	1·2			
2	403	1·2			
3	422	1·2			
4	404	1·2			
5	300	1·2			
6	301	1·2			
7	302	1·2			
8	317	1·2			
9	318	1·2			
10	319	1·2			
11	322	1·2			
12	348	1·2			
13	349	1·2			
14	350	1·2			
15	425	1·2			
16	405	1·2			
17	425	1·2			
18	313	1·2			
19	306	1·2			
20	314	12			
21	334	1·2			
22	343	1·2			
23	351	1·2			
24	344	1·2			
25	282	1·2			
26	283	1·2			
27	277	1·2			
28	273	1·2			
29	274	1·2			
30					
Totals	29	34·8			
Running Total	1068	1092·8			
Pre - Auger used on site for above date:				YES / NO (NO circled)	Chargeable Standing Time:

This is a true record of work carried out.

Vibro Menard Name: LEE CARTR **Signature:** [signature]

Client Name: Matt Coffey **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO MENARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
Daily Record Sheet – Vibro Stone Columns		Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	1 of	Contract Name:	POYLE	Contract Number:	6726
Date:	16/04/2024	Day:	TUESDAY	Week Ending:	19/04/24
Rig No:	ABI TM 13	Operator:	W-WALKER	Supervisor:	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	1010	0.8			
2	1011	0.8			
3	1012	0.8			
4	1013	0.8			
5	1014	0.8			
6	1015	0.8			
7	1016	0.8			
8	1017	0.8			
9	1018	0.8			
10	1019	0.8			
11	1020	0.8			
12	1021	0.8			
13	1022	0.8			
14	1023	0.8			
15	1036	0.8			
16	1037	0.8			
17	1038	0.8			
18	1039	0.8			
19	1040	0.8			
20	1041	0.8			
21	1042	0.8			
22	1043	0.8			
23	1044	0.8			
24	1045	0.8			
25	1046	0.8			
26	1047	0.8			
27	1048	0.8			
28	1049	0.8			
29	1050	0.8			
30	1051	0.8			
Totals	30	24			
Running Total	885	891.6			
Pre - Auger used on site for above date:				YES / NO (YES circled)	Chargeable Standing Time:

This is a true record of work carried out.

Vibro Menard Name: L CARTER **Signature:** [signature]

Client Name: Matt coffey **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO menard	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
Daily Record Sheet – Vibro Stone Columns		Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	2 of	Contract Name:	POYLE	Contract Number:	6726
Date:	16/04/2024	Day:	TUESDAY	Week Ending:	19/04/24
Rig No:	ABI TM 13	Operator:	W. WALKER	Supervisor:	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	1052	0.8			
2	1053	0.8			
3	1054	0.8			
4	1055	0.8			
5	1056	0.8			
6	1057	0.8			
7	1058	0.8			
8	1059	0.8			
9	157	1.0			
10	158	1.0			
11	163	1.0			
12	164	1.0			
13	165	1.0			
14	172	1.0			
15	173	1.0			
16	177	1.6			
17	178	1.6			
18	181	1.6			
19	182	1.6			
20	183	1.6			
21	187	1.6			
22	188	1.6			
23	189	1.6			
24	197	1.6			
25	198	1.6			
26	199	1.6			
27	200	1.6			
28	222	1.6			
29	223	1.6			
30	238	1.6			
Totals	30	37.4			
Running Total	915	929			
Pre - Auger used on site for above date:				YES / NO	Chargeable Standing Time:

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Vibro Menard Name: L CARTER Signature: [signature]

Client Name: Matt coffey Signature: [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

Sheet No:	3 of	Contract Name:	POYLE	Contract Number:	6726
Date:	16/04/2024	Day:	TUESDAY	Week Ending:	19/4/24
Rig No:	ABI TM 13	Operator:	W. WALKER	Supervisor:	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	239	1.6			
2	240	1.6			
3	241	1.6			
4	269	1.6			
5	270	1.6			
6	271	1.6			
7	272	1.6			
8	275	1.6			
9	276	1.6			
10	278	1.6			
11	279	1.6			
12	280	1.6			
13	281	1.6			
14	~~273~~				
15	~~274~~				
16	~~277~~				
17	~~282~~				
18	~~283~~				
19	284	0.8			
20	316	1.0			
21	315	1.0			
22	336	1.0			
23	335	1.0			
24	307	1.0			
25	337	1.0			
26	303	1.0			
27	323	1.0			
28	345	1.0			
29	308	1.0			
30	338	1.0			
Totals	26	32.6			
Running Total	941	961.6			

Pre - Auger used on site for above date:	YES / NO	Chargeable Standing Time:	

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Vibro Menard Name: LEE CARTER Signature: [signature]

Client Name: Matt Coffey Signature: [signature]

VIBRO MENARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
	Daily Record Sheet – Vibro Stone Columns	Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	4 of 6	Contract Name:	POYLE	Contract Number:	
Date:	16/04/2024	Day:	TUESDAY	Week Ending:	
Rig No:	ABI TM13	Operator:	W. WALKER	Supervisor:	

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	406	1.0			
2	393	1.0			
3	407	1.0			
4	309	1.0			
5	304	1.0			
6	310	1.0			
7	311	1.0			
8	305	1.0			
9	312	1.0			
10	324	1.0			
11	325	1.0			
12	339	1.0			
13	346	1.0			
14	340	1.0			
15	341	1.0			
16	347	1.0			
17	342	1.0			
18	408	1.0			
19	394	1.0			
20	409	1.0			
21	395	1.0			
22	410	1.0			
23	288	1.0			
24	289	1.0			
25	290	1.0			
26	326	1.0			
27	327	1.0			
28	355	1.0			
29	356	1.0			
30	357	1.0			
Totals	30	30			
Running Total	971	991.6			
Auger used on site for above date:				YES / NO	Chargeable Standing Time:

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Vibro Menard Name: LEE CARTER Signature: [signature]

Name: Matt Coffey Signature: [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO MENARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
	Daily Record Sheet – Vibro Stone Columns	Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	7 of 7	Contract Name:	POYLE	Contract Number:	6726
Date:	16/04/24	Day:	TUESDAY	Week Ending:	19/04/24
Rig No:	ABI TM13	Operator:	W. WALKER	Supervisor:	L. CARE

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	161	1.4			
2	156	1.4			
3	162	1.4			
4	167	1.4			
5	170	1.4			
6	174	1.4			
7	171	1.4			
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					
Totals	7	9.8			
Running Total	1039	1058.2			
Pre - Auger used on site for above date:				YES / NO	Chargeable Standing Time:

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Vibro Menard Name: L CARE Signature: [signature]

Client Name: Matt coffey Signature: [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO menard	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
	Daily Record Sheet – Vibro Stone Columns	Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	1 of	**Contract Name:**	POYLE	**Contract Number:**	6726
Date:	15/04/2024	**Day:**	MONDAY	**Week Ending:**	19/04/24
Rig No:	ABI TM 13	**Operator:**	W. WALKER	**Supervisor:**	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	833	0.8			
2	834	0.8			
3	835	0.8			
4	859	0.8			
5	860	0.8			
6	861	0.8			
7	881	0.8			
8	882	0.8			
9	883	0.8			
10	907	0.8			
11	908	0.6			
12	909	0.6			
13	930	0.6			
14	931	0.6			
15	932	0.6			
16	956	0.6			
17	957	0.6			
18	958	0.6			
19	983	0.6			
20	984	0.6			
21	985	0.6			
22	1002	0.6			
23	1003	0.6			
24	854	0.6			
25	829	0.6			
26	830	0.6			
27	831	0.6			
28	832	0.6			
29	856	0.6			
30	857	0.6			
Totals	30	20			
Running Total	655	670.5			
Pre - Auger used on site for above date:				(YES) NO	**Chargeable Standing Time:**

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER **Signature:** [signature]

Client Name: Matt coffey **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

Daily Record Sheet – Vibro Stone Columns

Sheet No:	2 of	**Contract Name:**	POYLE	**Contract Number:**	6726
Date:	15/04/2024	**Day:**	MONDAY	**Week Ending:**	19/04/24
Rig No:	ABI TM13	**Operator:**	W. WALKER	**Supervisor:**	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	858	0.8			
2	878	0.8			
3	879	0.8			
4	880	0.8			
5	898	0.8			
6	899	0.8			
7	903	0.8			
8	904	0.8			
9	905	0.8			
10	906	0.8			
11	926	0.8			
12	927	0.8			
13	928	0.8			
14	929	0.8			
15	951	0.8			
16	952	0.8			
17	953	0.8			
18	954	0.8			
19	955	0.8			
20	978	0.8			
21	979	0.8			
22	980	0.8			
23	981	0.8			
24	982	0.8			
25	1006	0.8			
26	836	0.8			
27	837	0.8			
28	838	0.8			
29	839	0.8			
30	840	0.8			
Totals	30	24			
Running Total	685	694.5			

Pre - Auger used on site for above date:	YES (circled) / NO	**Chargeable Standing Time:**	

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Vibro Menard Name: LEE CARTER **Signature:** [signature]

Client Name: Matt coffey **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO menard	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
Daily Record Sheet – Vibro Stone Columns		Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	3 of	**Contract Name:**	POYLE	**Contract Number:**	6726
Date:	15/04/2024	**Day:**	MONDAY	**Week Ending:**	19/04/2024
Rig No:	ABI TM13	**Operator:**	W-WALKER	**Supervisor:**	L-CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	841	0·6			
2	842	0·6			
3	862	0·6			
4	863	0·6			
5	864	0·6			
6	865	0·6			
7	884	0·6			
8	885	0·6			
9	886	0·6			
10	887	0·6			
11	910	0·7			
12	911	0·7			
13	912	0·7			
14	913	0·7			
15	933	0·7			
16	934	0·7			
17	935	0·7			
18	936	0·7			
19	959	0·7			
20	960	0·7			
21	961	0·7			
22	962	0·7			
23	986	0·7			
24	987	0·7			
25	988	0·7			
26	989	0·7			
27	1004	0·7			
28	901	0·7			
29	924	0·7			
30	949	0·7			
Totals	30	20			
Running Total	715	714·5			

Pre - Auger used on site for above date:	(YES) / NO	**Chargeable Standing Time:**	

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER **Signature:** [signature]

Client Name: Matt Coffey **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO MENARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
Daily Record Sheet – Vibro Stone Columns		Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	4 of	**Contract Name:**	POYLE	**Contract Number:**	6726
Date:	15/04/2024	**Day:**	MONDAY	**Week Ending:**	19/04/24
Rig No:	ABI TM13	**Operator:**	W. WALKER	**Supervisor:**	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	866	0.6			
2	867	0.6			
3	868	0.6			
4	869	0.6			
5	870	0.6			
6	888	0.6			
7	E1	0.6			
8	E2	0.6			
9	889	0.6			
10	890	0.6			
11	902	0.6			
12	914	0.6			
13	E3	0.6			
14	E4	0.6			
15	915	0.6			
16	916	0.6			
17	917	0.6			
18	918	0.6			
19	919	0.6			
20	920	0.6			
21	921	0.6			
22	922	0.6			
23	923	0.6			
24	900	0.6			
25	925	0.6			
26	937	0.6			
27	938	0.6			
28	939	0.6			
29	940	0.6			
30	941	0.6			
Totals	30	18			
Running Total	745	732.5			
Pre - Auger used on site for above date:				(YES) / NO	**Chargeable Standing Time:**

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER **Signature:** [signature]

Client Name: Matt coffey **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO menARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
Daily Record Sheet – Vibro Stone Columns		Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	5 of	**Contract Name:**	POYLE	**Contract Number:**	6726
Date:	15/04/2024	**Day:**	MONDAY	**Week Ending:**	19/4/24
Rig No:	ABI TM13	**Operator:**	W-WALKER	**Supervisor:**	L-CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	942	0.7			
2	943	0.7			
3	944	0.7			
4	945	0.7			
5	946	0.7			
6	947	0.7			
7	948	0.7			
8	950	0.7			
9	963	0.7			
10	964	0.7			
11	965	0.7			
12	966	0.7			
13	967	0.7			
14	968	0.7			
15	969	0.7			
16	970	0.7			
17	971	0.7			
18	972	0.7			
19	973	0.7			
20	974	0.7			
21	975	0.7			
22	976	0.7			
23	977	0.7			
24	990	0.7			
25	991	0.7			
26	992	0.7			
27	993	0.7			
28	994	0.7			
29	995	0.7			
30	996	0.7			
Totals	30	21			
Running Total	775	753.5			
Pre - Auger used on site for above date:				(YES) / NO	**Chargeable Standing Time:**

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER **Signature:** [signature]

Client Name: Matt coffey **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO MENARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
	Daily Record Sheet – Vibro Stone Columns	Issue Date: 08/01/18
		Page: 1 of 1

Sheet No: 6 of 8 **Contract Name:** POYLE **Contract Number:** 67-26
Date: 15/04/2024 **Day:** MONDAY **Week Ending:** 19/4/24
Rig No: ABI TM13 **Operator:** W. WALKER **Supervisor:** L.CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	997	0.6			
2	998	0.6			
3	999	0.6			
4	1000	0.6			
5	1001	0.6			
6	191	0.6			
7	1005	0.6			
8	1007	0.6			
9	176	2.0			
10	179	2.0			
11	180	2.0			
12	184	2.0			
13	185	2.0			
14	186	2.0			
15	190	2.0			
16	219	1.8			
17	220	1.8			
18	235	1.8			
19	260	1.8			
20	261	1.8			
21	195	1.8			
22	196	1.8			
23	221	1.8			
24	236	1.8			
25	237	1.8			
26	262	1.8			
27	265	1.8			
28	266	1.8			
29	263	1.8			
30	264	1.8			
Totals	30	45.8			
Running Total	805	799.3			

Pre - Auger used on site for above date: (YES) / NO **Chargeable Standing Time:**

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER **Signature:** [signature]

Client Name: Matt coffey **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO menard	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
Daily Record Sheet – Vibro Stone Columns		Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	7 of 8	**Contract Name:**	POYLE	**Contract Number:**	6726
Date:	15/04/2024	**Day:**	MONDAY	**Week Ending:**	19/04/24
Rig No:	ABI TM13	**Operator:**	W. WALKER	**Supervisor:**	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	233	1.8			
2	234	1.8			
3	192	1.8			
4	193	1.8			
5	194	1.8			
6	213	1.4			
7	214	1.4			
8	230	1.4			
9	254	1.4			
10	255	1.4			
11	211	1.4			
12	212	1.4			
13	229	1.4			
14	252	1.4			
15	253	1.4			
16	209	1.1			
17	210	1.1			
18	228	1.1			
19	250	1.1			
20	251	1.1			
21	207	1.2			
22	208	1.2			
23	227	1.2			
24	248	1.2			
25	249	1.2			
26	205	1.2			
27	206	1.2			
28	226	1.2			
29	246	1.2			
30	247	1.2			
Totals	30	40.5			
Running Total	835	839.8			

Pre - Auger used on site for above date:	(YES circled) / NO	**Chargeable Standing Time:**	

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER **Signature:** [signature]

Client Name: Matt coffey **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO MENARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
Daily Record Sheet – Vibro Stone Columns		Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	8 of 8	**Contract Name:**	POYLE	**Contract Number:**	6726
Date:	15/04/2024	**Day:**	MONDAY	**Week Ending:**	19/04/24
Rig No:	ABI TM13	**Operator:**	W. WALKER	**Supervisor:**	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	1035	1.8			
2	268	1.8			
3	267	1.8			
4	1034	1.6			
5	1033	0.8			
6	1032	0.8			
7	1031	0.8			
8	1030	0.8			
9	1029	0.8			
10	1028	0.8			
11	1027	0.8			
12	1026	0.8			
13	1025	0.8			
14	1024	0.8			
15	203	1.4			
16	204	1.4			
17	225	1.4			
18	244	1.4			
19	245	1.4			
20	201	1.2			
21	202	1.2			
22	224	1.2			
23	242	1.2			
24	243	1.2			
25					
26					
27					
28					
29					
30					
Totals	24	28			
Running Total	~~[illegible]~~ 859	867.8			
Pre - Auger used on site for above date:				(YES) / NO	**Chargeable Standing Time:**

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER **Signature:** [signature]

Client Name: Matt Coffey **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO menARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
Daily Record Sheet – Vibro Stone Columns		Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	1 of	Contract Name:	POYLE	Contract Number:	6726
Date:	12/04/24	Day:	FRIDAY	Week Ending:	12/04/24
Rig No:	ABI TM13	Operator:	W. WALKER	Supervisor:	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	812	0.8			
2	813	0.8			
3	814	0.8			
4	815	0.8			
5	788	0.8			
6	789	0.8			
7	790	0.8			
8	791	0.8			
9	761	0.8			
10	762	0.8			
11	763	0.8			
12	764	0.8			
13	738	0.8			
14	739	0.8			
15	740	0.8			
16	715	0.8			
17	716	0.8			
18	717	0.8			
19	687	0.8			
20	688	0.8			
21	689	0.8			
22	690	0.8			
23	663	0.8			
24	664	0.8			
25	665	0.8			
26	666	0.8			
27	638	0.8			
28	639	0.8			
29	640	0.8			
30	641	0.8			
Totals	30	24			
Running Total	538	560			
Pre - Auger used on site for above date:				YES / NO	Chargeable Standing Time:

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER **Signature:** [signature]

Client Name: Matt Coffey **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO MENARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
Daily Record Sheet – Vibro Stone Columns		Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	2 of	**Contract Name:**	POYLE	**Contract Number:**	6726
Date:	12/04/2024	**Day:**	FRIDAY	**Week Ending:**	12/04/24
Rig No:	ABI TM13	**Operator:**	W. WALKER	**Supervisor:**	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	613	0.8			
2	614	0.8			
3	615	0.8			
4	591	0.8			
5	592	0.8			
6	593	0.8			
7	564	0.8			
8	565	0.8			
9	566	0.8			
10	567	0.8			
11	568	0.8			
12	539	0.8			
13	540	0.8			
14	541	0.8			
15	542	0.8			
16	543	0.8			
17	516	0.8			
18	517	0.8			
19	518	0.8			
20	491	0.8			
21	492	0.8			
22	475	0.8			
23	476	0.8			
24	453	1.0			
25	464	1.0			
26	465	1.0			
27	451	1.0			
28	452	1.0			
29	440	1.0			
30	441	1.0			
Totals	30	25.4			
Running Total	568	585.4			

Pre - Auger used on site for above date:	**YES / NO**	**Chargeable Standing Time:**	

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER **Signature:** [signature]

Client Name: Matt Coffey **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO menARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
Daily Record Sheet – Vibro Stone Columns		Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	3 of	**Contract Name:**	POYLE	**Contract Number:**	6726
Date:	12/04/2024	**Day:**	FRIDAY	**Week Ending:**	12/04/24
Rig No:	ABI TM13	**Operator:**	W. WALKER	**Supervisor:**	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	25	1·3			
2	26	1·3			
3	28	1·3			
4	29	1·3			
5	30	1·3			
6	33	1·3			
7	34	1·3			
8	1	1·4			
9	2	1·4			
10	3	1·4			
11	11	1·4			
12	12	1·4			
13	20	1·4			
14	21	1·4			
15	22	1·4			
16	10	1·2			
17	15	12			
18	426	1·0			
19	5	1·2			
20	4	1·2			
21	17	1·2			
22	16	1·2			
23	427	1·0			
24	7	1·2			
25	6	1·2			
26	19	1·2			
27	18	12			
28	429	1·0			
29	8	1·2			
30	13	1·2			
Totals	30	37·7			
Running Total	598	623·1			
Pre - Auger used on site for above date:				YES / NO (YES circled)	**Chargeable Standing Time:**

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER **Signature:** [signature]

Client Name: Matt Coffey **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO menARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
Daily Record Sheet – Vibro Stone Columns		Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	4 of	Contract Name:	POYLE	Contract Number:	6726
Date:	12/04/2024	Day:	FRIDAY	Week Ending:	12/04/24
Rig No:	ABI TM13	Operator:	W. WALKER	Supervisor:	

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	430	1.0			
2	428	1.0			
3	9	1.2			
4	14	1.2			
5	432	1.0			
6	433	1.0			
7	434	1.0			
8	435	1.0			
9	436	1.0			
10	437	1.0			
11	438	1.0			
12	439	1.0			
13	443	1.0			
14	444	1.0			
15	445	1.0			
16	446	1.0			
17	447	1.0			
18	448	1.0			
19	449	1.0			
20	456	1.0			
21	457	1.0			
22	458	1.0			
23	459	1.0			
24	460	1.0			
25	461	1.0			
26	462	1.0			
27	463	1.0			
28					
29					
30					
Totals	27	27.4			
Running Total	625	650.5			
Pre - Auger used on site for above date:				YES / NO (YES circled)	Chargeable Standing Time:

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER

Signature:

Client Name: Matt coffey

Signature:

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO menARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
	Daily Record Sheet – Vibro Stone Columns	Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	1 of 6	Contract Name:	POYLE	Contract Number:	6726
Date:	11/04/2024	Day:	THURSDAY	Week Ending:	12/04/24
Rig No:	ABI TM13	Operator:	W. WALKER	Supervisor:	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	467	0.8			
2	468	0.8			
3	469	0.8			
4	470	0.8			
5	471	0.8			
6	472	0.8			
7	473	0.8			
8	474	0.8			
9	483	0.8			
10	484	0.8			
11	485	0.8			
12	486	0.8			
13	487	0.8			
14	488	0.8			
15	489	0.8			
16	490	0.8			
17	508	0.8			
18	509	0.8			
19	510	0.8			
20	511	0.8			
21	512	0.8			
22	513	0.8			
23	514	0.8			
24	515	0.8			
25	533	0.8			
26	534	0.8			
27	535	0.8			
28	536	0.8			
29	537	0.8			
30	538	0.8			
Totals	30	24			
Running Total	364	399.5			
Pre - Auger used on site for above date:				YES (circled) / NO	Chargeable Standing Time:

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER **Signature:** [signature]

Client Name: Matt Coffey **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

Sheet No:	2 of 6	Contract Name:	POYLE	Contract Number:	6726
Date:	11/04/2024	Day:	THURSDAY	Week Ending:	12/04/24
Rig No:	ABI TM13	Operator:	W. WALLCOC	Supervisor:	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	558	0.8			
2	559	0.8			
3	560	0.8			
4	561	0.8			
5	562	0.8			
6	563	0.8			
7	584	0.8			
8	585	0.8			
9	586	0.8			
10	587	0.8			
11	588	0.8			
12	589	0.8			
13	590	0.8			
14	606	0.8			
15	607	0.8			
16	608	0.8			
17	609	0.8			
18	610	0.8			
19	611	0.8			
20	612	0.8			
21	631	0.8			
22	632	0.8			
23	633	0.8			
24	634	0.8			
25	635	0.8			
26	636	0.8			
27	637	0.8			
28	656	0.8			
29	657	0.8			
30	658	0.8			
Totals	30	24			
Running Total	394	423.5			
Pre - Auger used on site for above date:				(YES) NO	Chargeable Standing Time:

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER Signature: [signature]

Client Name: Matt coffey Signature: [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO MENARD

Business Management System

Ref №: VM/FORM/4024
Issue: 02
Issue Date: 08/01/18
Page: 1 of 1

Daily Record Sheet – Vibro Stone Columns

Sheet No:	3 of 6	Contract Name:	POYLE	Contract Number:	6726
Date:	11/04/2024	Day:	THURSDAY	Week Ending:	12/04/24
Rig No:	ABI TM 13	Operator:	W. WALKER	Supervisor:	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	659	0.8			
2	660	0.8			
3	661	0.8			
4	662	0.8			
5	680	0.8			
6	681	0.8			
7	682	0.8			
8	683	0.8			
9	684	0.8			
10	685	0.8			
11	686	0.8			
12	707	0.8			
13	708	0.8			
14	709	0.8			
15	710	0.8			
16	711	0.8			
17	712	0.8			
18	713	0.8			
19	714	0.8			
20	731	0.8			
21	732	0.8			
22	733	0.8			
23	734	0.8			
24	735	0.8			
25	736	0.8			
26	737	0.8			
27	754	0.8			
28	755	0.8			
29	756	0.8			
30	757	0.8			
Totals	30	24			
Running Total	424	447.5			

Pre - Auger used on site for above date: (YES) / NO — Chargeable Standing Time:

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER — **Signature:** [signature]

Client Name: Matt Coffey — **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO MENARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
Daily Record Sheet – Vibro Stone Columns		Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	4 of 6	Contract Name:	POYLE	Contract Number:	6726
Date:	11/04/2024	Day:	THURSDAY	Week Ending:	12/04/24
Rig No:	ABI TM13	Operator:	W-WALKER	Supervisor:	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	758	0·8			
2	759	0·8			
3	760	0·8			
4	781	0·8			
5	782	0·8			
6	783	0·8			
7	784	0·8			
8	785	0·8			
9	786	0·8			
10	787	0·8			
11	805	0·8			
12	806	0·8			
13	807	0·8			
14	808	0·8			
15	809	0·8			
16	810	0·8			
17	811	0·8			
18	141	1·0			
19	142	1·0			
20	146	1·0			
21	147	1·0			
22	148	1·0			
23	150	1·0			
24	151	1·0			
25	779	0·80			
26	780	0·8			
27	122	1·2			
28	123	1·2			
29	128	1·2			
30	129	1·2			
Totals	30	27			
Running Total	454	474·5			

Pre - Auger used on site for above date: YES (circled) / NO

Chargeable Standing Time:

This is a true record of work carried out.

Vibro Menard Name: L CARTER Signature: [signature]

Client Name: Matt Coffey Signature: [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO MENARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
Daily Record Sheet – Vibro Stone Columns		Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	5 of 6	**Contract Name:**	POYLE	**Contract Number:**	6726
Date:	11/04/2024	**Day:**	THURSDAY	**Week Ending:**	12/04/24
Rig No:	ABI TM13	**Operator:**	W. WALKER	**Supervisor:**	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	130	1.2			
2	135	1.2			
3	136	1.2			
4	704	0.8			
5	705	0.8			
6	109	1.2			
7	110	1.2			
8	113	1.2			
9	114	1.2			
10	115	1.2			
11	117	1.2			
12	118	1.2			
13	629	0.8			
14	630	0.8			
15	89	1.2			
16	90	1.2			
17	95	1.2			
18	96	1.2			
19	97	1.2			
20	103	1.2			
21	104	1.2			
22	582	0.8			
23	557	0.8			
24	74	1.3			
25	75	1.3			
26	79	1.3			
27	80	1.3			
28	81	1.3			
29	82	1.3			
30	83	1.3			
Totals	30	34.3			
Running Total	484	508.8			
Pre - Auger used on site for above date:				YES (circled) / NO	**Chargeable Standing Time:**

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER **Signature:** [signature]

Client Name: **Signature:**

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO menARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
Daily Record Sheet – Vibro Stone Columns		Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	6 of 6	**Contract Name:**	POYLE	**Contract Number:**	6726
Date:	11/04/2024	**Day:**	THURSDAY	**Week Ending:**	12/04/24
Rig No:	ABI TM13	**Operator:**	W. WALKER	**Supervisor:**	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	506	0.8			
2	507	0.8			
3	482	0.8			
4	466	0.8			
5	455	0.8			
6	442	0.8			
7	431	0.8			
8	454	0.8			
9	23	1.4			
10	24	1.4			
11	27	1.4			
12	31	1.4			
13	32	1.4			
14	36	1.4			
15	35	1.4			
16	37	1.4			
17	40	1.2			
18	41	1.2			
19	43	1.2			
20	55	1.2			
21	56	1.2			
22	68	1.2			
23	69	1.2			
24	66	1.2			
25					
26					
27					
28					
29					
30					
Totals	24	27.2			
Running Total	508	536			
Pre - Auger used on site for above date:				(YES) NO	**Chargeable Standing Time:**

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER **Signature:** [signature]

Client Name: Matt Coffey **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO MENARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
	Daily Record Sheet – Vibro Stone Columns	Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	1 of 3	Contract Name:	POYLE	Contract Number:	6726
Date:	10/04/2024	Day:	WEDNESDAY	Week Ending:	12/04/24
Rig No:	ABI TM13	Operator:	W. WALKER	Supervisor:	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	1009	1.0			
2	217	2.0			
3	218	3.0			
4	232	2.0			
5	258	2.0			
6	259	2.0			
7	1008	1.3			
8	256	3.0			
9	257	2.6			
10	231	2.0			
11	215	2.0			
12	216	2.0			
13	877	1.0			
14	897	1.0			
15	159	1.5			
16	155	1.5			
17	160	1.5			
18	166	1.5			
19	168	1.5			
20	169	1.5			
21	175	1.5			
22	72	2.0			
23	77	2.0			
24	85	2.0			
25	76	2.0			
26	84	2.0			
27	73	2.0			
28	78	2.0			
29	86	2.0			
30	59	1.0			
Totals	30	54.4			
Running Total	296	329.9			
Pre - Auger used on site for above date:				(YES) NO	Chargeable Standing Time:

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER Signature: [signature]

Client Name: Matt coffey Signature: [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO MENARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
	Daily Record Sheet – Vibro Stone Columns	Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	2 of 3	**Contract Name:**	POYLE	**Contract Number:**	6726
Date:	10/04/2024	**Day:**	WEDNESDAY	**Week Ending:**	12/04/24
Rig No:	ABI TM13	**Operator:**	W. WALKER	**Supervisor:**	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	52	1.0			
2	58	1.0			
3	51	1.0			
4	49	1.2			
5	47	1.2			
6	65	1.2			
7	63	1.2			
8	48	1.0			
9	46	1.0			
10	64	1.0			
11	62	1.0			
12	50	1.2			
13	57	1.2			
14	38	1.2			
15	44	1.2			
16	60	1.2			
17	70	1.2			
18	67	1.2			
19	54	1.2			
20	42	1.2			
21	39	1.2			
22	45	1.2			
23	61	1.2			
24	72	1.2			
25	91	1.4			
26	100	1.4			
27	105	1.4			
28	98	1.4			
29	87	1.4			
30	92	1.4			
Totals	30	34.4			
Running Total	326	364.3			

Pre - Auger used on site for above date: (YES) / NO — **Chargeable Standing Time:**

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER **Signature:** [signature]

Client Name: [signature] **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO MENARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
	Daily Record Sheet – Vibro Stone Columns	Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	3 of 3	Contract Name:	POYLE	Contract Number:	6726
Date:	10/04/2024	Day:	WEDNESDAY	Week Ending:	12/04/24
Rig No:	ABI TM13	Operator:	W. WALKER	Supervisor:	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	101	1.4			
2	126	1.4			
3	133	1.4			
4	121	1.4			
5	131	1.4			
6	139	1.4			
7	127	1.4			
8	134	1.4			
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					
Totals	8	11.2			
Running Total	334	375.5			
Pre - Auger used on site for above date:				(YES) / NO	Chargeable Standing Time:

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER Signature: [signature]

Client Name: Matt coffey Signature: [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO MENARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
Daily Record Sheet – Vibro Stone Columns		Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	1 of 5	**Contract Name:**	POYLE	**Contract Number:**	6726
Date:	09/04/2024	**Day:**	TUESDAY	**Week Ending:**	12/04/24
Rig No:	ABI TM13	**Operator:**	W. WALKER	**Supervisor:**	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	571	1.0			
2	572	1.0			
3	573	1.0			
4	574	1.0			
5	575	1.0			
6	595	1.0			
7	596	1.0			
8	597	1.0			
9	598	1.0			
10	599	1.0			
11	617	1.0			
12	618	1.0			
13	619	1.0			
14	620	1.0			
15	621	1.0			
16	622	1.0			
17	623	1.0			
18	624	1.0			
19	625	1.0			
20	626	1.0			
21	644	1.0			
22	645	1.0			
23	646	1.0			
24	647	1.0			
25	648	1.0			
26	649	1.0			
27	650	1.0			
28	651	1.0			
29	652	1.0			
30	653	1.0			
Totals	30	30			
Running Total	148	161.5			
Pre - Auger used on site for above date:				~~YES~~ / NO	**Chargeable Standing Time:**

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER **Signature:** [signature]

Client Name: Matt Coffey **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO MENARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
Daily Record Sheet – Vibro Stone Columns		Issue Date: 08/01/18
		Page: 1 of 1

Sheet No: 2 of 5 **Contract Name:** POYLE **Contract Number:** 6726
Date: 09/04/2024 **Day:** TUESDAY **Week Ending:** 12/04/24
Rig No: ABI TM13 **Operator:** W. WALKER **Supervisor:** L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	669	1·0			
2	670	1·0			
3	671	1·0			
4	672	1·0			
5	673	1·0			
6	674	1·0			
7	675	1·0			
8	676	1·0			
9	677	1·0			
10	678	1·0			
11	693	1·0			
12	694	1·0			
13	695	1·0			
14	696	1·0			
15	697	1·0			
16	698	1·0			
17	699	1·0			
18	700	1·0			
19	701	1·0			
20	702	1·0			
21	720	1·0			
22	721	1·0			
23	722	1·0			
24	723	1·0			
25	724	1·0			
26	725	1·0			
27	726	1·0			
28	727	1·0			
29	728	1·0			
30	729	1·0			
Totals	30	30			
Running Total	178	191·5			
Pre - Auger used on site for above date:				~~YES~~ / NO	Chargeable Standing Time:

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER **Signature:** [signature]

Client Name: Matt coffey **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO MENARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
	Daily Record Sheet – Vibro Stone Columns	Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	3 of 5	**Contract Name:**	POYLE	**Contract Number:**	6728
Date:	09/04/2024	**Day:**	TUESDAY	**Week Ending:**	12/4/24
Rig No:	ABI TM13	**Operator:**	W. WALKER	**Supervisor:**	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	744	1.0			
2	745	1.0			
3	746	1.0			
4	747	1.0			
5	748	1.0			
6	749	1.0			
7	750	1.0			
8	751	1.0			
9	752	1.0			
10	753	1.0			
11	767	1.0			
12	768	1.0			
13	769	1.0			
14	770	1.0			
15	771	1.0			
16	772	1.0			
17	773	1.0			
18	774	1.0			
19	775	1.0			
20	776	1.0			
21	794	1.0			
22	795	1.0			
23	796	1.0			
24	797	1.0			
25	798	1.0			
26	799	1.0			
27	800	1.0			
28	801	1.0			
29	802	1.0			
30	803	1.0			
Totals	30	30			
Running Total	208	221.5			
Pre - Auger used on site for above date:				~~YES~~ / NO	**Chargeable Standing Time:**

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER **Signature:** [signature]

Client Name: Matt coffey **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO menard	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
Daily Record Sheet – Vibro Stone Columns		Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	4 of 5	**Contract Name:**	POYLE	**Contract Number:**	6726
Date:	09/04/2024	**Day:**	TUESDAY	**Week Ending:**	12/03/24
Rig No:	ABI TM13	**Operator:**	W. WALKER	**Supervisor:**	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	818	1.0			
2	819	1.0			
3	820	1.0			
4	821	1.0			
5	822	1.0			
6	823	1.0			
7	824	1.0			
8	825	1.0			
9	826	1.0			
10	827	1.0			
11	843	1.0			
12	844	1.0			
13	845	1.0			
14	846	1.0			
15	847	1.0			
16	848	1.0			
17	849	1.0			
18	850	1.0			
19	851	1.0			
20	852	1.0			
21	604	1.0			
22	891	1.0			
23	892	1.0			
24	893	1.0			
25	894	1.0			
26	895	1.0			
27	896	1.0			
28	871	1.0			
29	872	1.0			
30	873	1.0			
Totals	30	30			
Running Total	238	251.5			
Pre - Auger used on site for above date:				~~YES~~ / NO	**Chargeable Standing Time:**

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER **Signature:** [signature]

Client Name: Matt coffey **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO MENARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
	Daily Record Sheet – Vibro Stone Columns	Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	5 of 5	**Contract Name:**	POYLE	**Contract Number:**	6726
Date:	09/04/24	**Day:**	TUESDAY	**Week Ending:**	12/04/24
Rig No:	ABI TM13	**Operator:**	W. WALKER	**Supervisor:**	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	874	1·0			
2	875	1·0			
3	876	1·0			
4	816	1·0			
5	817	1·0			
6	792	1·0			
7	793	1·0			
8	765	1·0			
9	766	1·0			
10	742	1·0			
11	743	1·0			
12	718	1·0			
13	719	1·0			
14	691	1·0			
15	692	1·0			
16	667	1·0			
17	668	1·0			
18	642	1·0			
19	643	1·0			
20	616	1·0			
21	544	1·0			
22	570	1·0			
23	545	1·0			
24	569	1·0			
25	583	1·0			
26	605	1·0			
27	88	1·2			
28	94	1·2			
29					
30					
Totals	28	~~[illegible]~~ 28·4			
Running Total	266	279·7			
Pre - Auger used on site for above date:				~~YES~~ / NO	**Chargeable Standing Time:**

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER **Signature:** [signature]

Client Name: Matt Coffey **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO MENARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
Daily Record Sheet – Vibro Stone Columns		Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	1 of 4	**Contract Name:**	POYLE	**Contract Number:**	6726
Date:	08/04/2024	**Day:**	MONDAY	**Week Ending:**	12/04/24
Rig No:	ABI TM13	**Operator:**	W. WALKER	**Supervisor:**	L-CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	379	1·5			
2	372	1·5			
3	378	1·4			
4	371	1·4			
5	377	1·2			
6	370	1·2			
7	376	1·2			
8	369	1·2			
9	375	1·2			
10	368	1·2			
11	374	1·2			
12	367	1·2			
13	373	1·2			
14	93	1·0			
15	99	1·0			
16	627	1·0			
17	102	1·0			
18	106	1·0			
19	107	1·0			
20	108	1·0			
21	628	1·0			
22	654	1·2			
23	655	1·2			
24	679	1·2			
25	111	1·2			
26	112	1·2			
27	116	1·2			
28	119	1·2			
29	120	1·2			
30	703	1·2			
Totals	30	35·4			
Running Total	30	35·4			
Pre - Auger used on site for above date:				YES / NO	**Chargeable Standing Time:**

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER **Signature:** [signature]

Client Name: matt coffey **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO menARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
Daily Record Sheet – Vibro Stone Columns		Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	2 of 4	**Contract Name:**	POYLE	**Contract Number:**	6726
Date:	08/04/2024	**Day:**	MONDAY	**Week Ending:**	12/04/24
Rig No:	ABT TM 13	**Operator:**	W. WALKER	**Supervisor:**	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	730	1.5			
2	706	1.5			
3	741	2.0			
4	124	2.0			
5	125	2.0			
6	132	2.0			
7	137	2.0			
8	138	2.0			
9	777	1.7			
10	778	1.7			
11	804	1.5			
12	828	1.5			
13	143	1.5			
14	149	1.5			
15	140	1.5			
16	145	1.5			
17	152	1.5			
18	144	1.5			
19	153	1.5			
20	154	1.5			
21	386	1.5			
22	853	1.5			
23	855	1.5			
24	380	1.5			
25	387	1.5			
26	381	1.5			
27	388	1.5			
28	382	1.5			
29	389	1.5			
30	383	1.5			
Totals	30	48.4			
Running Total	60	83.8			

Pre - Auger used on site for above date:	~~YES~~ / NO	**Chargeable Standing Time:**

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER **Signature:** [signature]

Client Name: Matt coffey **Signature:** [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO MENARD

Business Management System

Ref №: VM/FORM/4024	Issue: 02
Issue Date: 08/01/18	Page: 1 of 1

Daily Record Sheet – Vibro Stone Columns

Sheet No:	3 of 4	Contract Name:	POYLE	Contract Number:	6726
Date:	08/04/2024	Day:	MONDAY	Week Ending:	12/04/24
Rig No:	ABI TM13	Operator:	W. WALKER	Supervisor:	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	390	1.3			
2	384	1.3			
3	391	1.3			
4	385	1.1			
5	392	1.1			
6	477	0.8			
7	478	0.8			
8	479	0.8			
9	480	0.8			
10	481	0.8			
11	53	0.8			
12	493	0.8			
13	494	0.8			
14	495	0.8			
15	496	0.8			
16	497	0.8			
17	498	0.8			
18	499	0.8			
19	500	0.8			
20	501	0.8			
21	502	0.8			
22	503	0.8			
23	504	0.8			
24	505	0.8			
25	520	0.8			
26	521	0.8			
27	522	0.8			
28	523	0.8			
29	524	0.8			
30	525	0.8			
Totals	30	25.3			
Running Total	90	109.1			
Pre - Auger used on site for above date:				~~YES~~ / NO	Chargeable Standing Time:

This is a true record of work carried out.

Vibro Menard Name: LEE CARTER — Signature: [signature]

Client Name: Matt coffey — Signature: [signature]

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

VIBRO MENARD	Business Management System	Ref №: VM/FORM/4024
		Issue: 02
Daily Record Sheet – Vibro Stone Columns		Issue Date: 08/01/18
		Page: 1 of 1

Sheet No:	4 of 4	**Contract Name:**	POYLE	**Contract Number:**	6726
Date:	08/04/2024	**Day:**	MONDAY	**Week Ending:**	12/04/24
Rig No:	ABI TM13	**Operator:**	W. WALKER	**Supervisor:**	L. CARTER

No.	Column Reference	Depth (m)	Stone Used (T)	Pen/Comp (amps / bar)	Comments (e.g. Plot number, ground conditions, obstructions, delays, variation of stone consumption)
1	526	0.8			
2	527	0.8			
3	528	0.8			
4	529	0.8			
5	530	0.8			
6	531	0.8			
7	532	0.8			
8	546	0.8			
9	547	0.8			
10	548	0.8			
11	549	0.8			
12	550	0.8			
13	551	0.8			
14	552	0.8			
15	553	0.8			
16	554	0.8			
17	555	0.8			
18	556	0.8			
19	581	0.8			
20	580	0.8			
21	579	0.8			
22	578	0.8			
23	577	0.8			
24	576	0.8			
25	603	0.8			
26	602	0.8			
27	601	0.8			
28	600	0.8			
29					
30					
Totals	28	22.4			
Running Total	118	131.5			
Pre - Auger used on site for above date:				~~YES~~ / NO	**Chargeable Standing Time:**

This is a true record of work carried out.

Vibro Menard Name: Lee Carter **Signature:**

Client Name: Matt coffey **Signature:**

Issue	Page(s)	Revision Description	Prepared By	Reviewed By
02	01	Current	David Rickson	Marc Evans

menard	Business Management System	VM/FORM/4009 Issue: 03
	Plate Load Test	Issue Date: 23/08/2023 Page: 1

Contract Name: Poyle

Contract No: 6726

Installation Date: 10.04.2024

Date of Test: 10.04.2024

Test Depth: 0.3

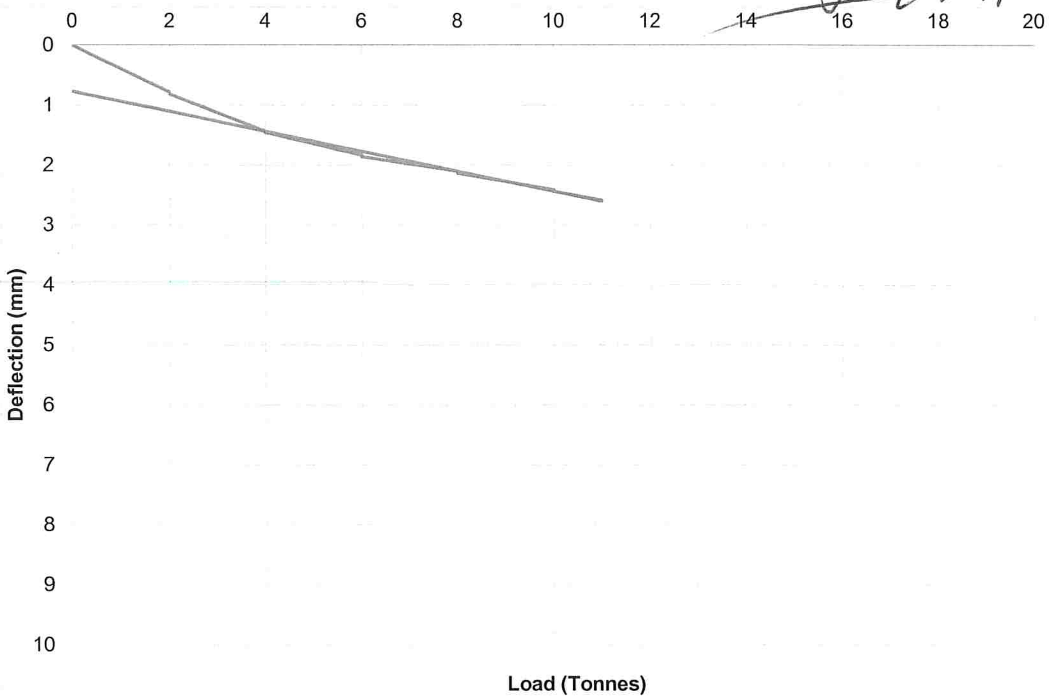
Test Number: 1

Column No: 216

Plate Size: 600mm

Approved By:

Elapsed Time (mins)	Load (tonnes)	Gauge Readings				Gauge Deflections				Average Deflection (mm)
		1	2	3	4	1	2	3	4	
0	0	0	0	0						
1	2	-81	-77	-79		81	77	79		0.79
4	2	-82	-79	-81		82	79	81		0.81
5	2	-83	-80	-82		83	80	82		0.82
6	4	-146	-144	-141		146	144	141		1.44
9	4	-147	-146	-143		147	146	143		1.45
10	4	-148	-146	-144		148	146	144		1.46
11	6	-181	-186	-185		181	186	185		1.84
14	6	-183	-187	-186		183	187	186		1.85
15	6	-184	-187	-188		184	187	188		1.86
16	8	-209	-214	-210		209	214	210		2.11
19	8	-211	-216	-213		211	216	213		2.13
20	8	-212	-216	-214		212	216	214		2.14
21	10	-239	-244	-241		239	244	241		2.41
24	10	-241	-245	-243		241	245	243		2.43
25	10	-243	-246	-243		243	246	243		2.44
26	11	-257	-261	-259		257	261	259		2.59
29	11	-259	-262	-259		259	262	259		2.60
30	11	-260	-262	-260		260	262	260		2.61
0	0	-74	-81	-77		74	81	77		0.77
5	0	-75	-80	-76		75	80	76		0.77



Issue	Pages	Revision Description	Prepared By	Reviewed By
3	1	Current	David Rickson	Marc Evans

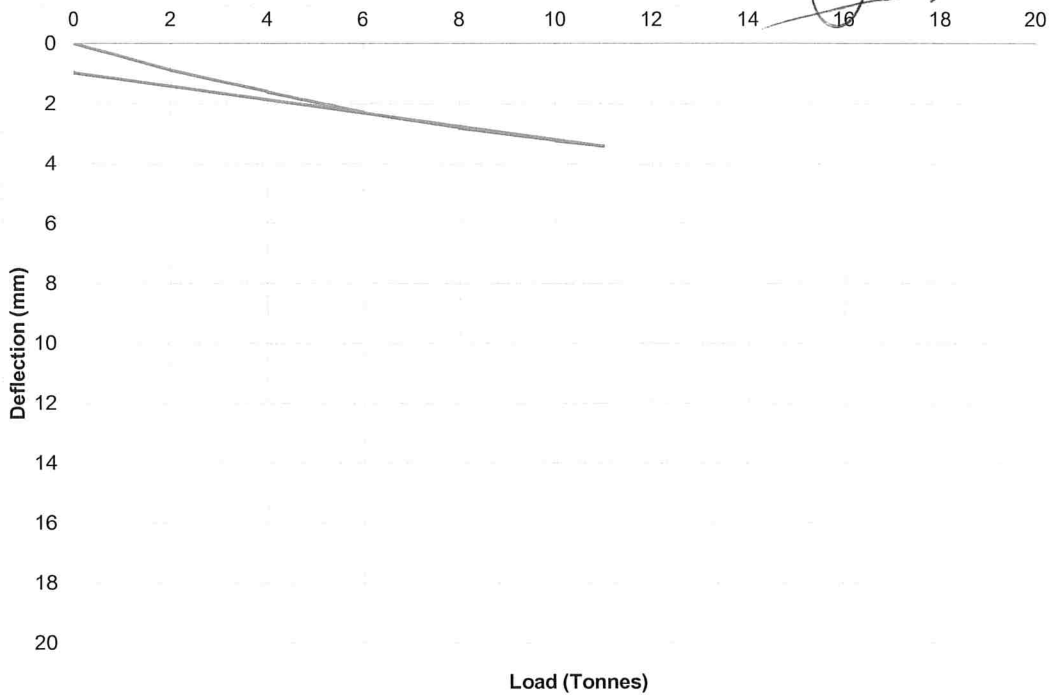
menard	Business Management System	VM/FORM/4009
		Issue: 03
	Plate Load Test	Issue Date: 23/08/2023
		Page: 1

Contract Name:	Poyle
Installation Date:	10.04.2024
Test Depth:	0.3
Column No:	798

Contract No:	6726
Date of Test:	10.04.2024
Test Number:	2
Plate Size:	600mm

Approved By:

Elapsed Time (mins)	Load (tonnes)	Gauge Readings				Gauge Deflections				Average Deflection (mm)
		1	2	3	4	1	2	3	4	
0	0	0	0	0						
1	2	-90	-88	-85		90	88	85		0.88
4	2	-92	-89	-86		92	89	86		0.89
5	2	-93	-89	-87		93	89	87		0.90
6	4	-166	-159	-155		166	159	155		1.60
9	4	-167	-160	-156		167	160	156		1.61
10	4	-168	-161	-157		168	161	157		1.62
11	6	-232	-229	-227		232	229	227		2.29
14	6	-233	-230	-228		233	230	228		2.30
15	6	-234	-230	-229		234	230	229		2.31
16	8	-279	-283	-280		279	283	280		2.81
19	8	-280	-284	-281		280	284	281		2.82
20	8	-281	-284	-282		281	284	282		2.82
21	10	-321	-323	-325		321	323	325		3.23
24	10	-322	-324	-326		322	324	326		3.24
25	10	-323	-324	-326		323	324	326		3.24
26	11	-339	-341	-344		339	341	344		3.41
29	11	-340	-342	-345		340	342	345		3.42
30	11	-341	-342	-346		341	342	346		3.43
0	0	-96	-99	-98		96	99	98		0.98
5	0	-95	-97	-96		95	97	96		0.96



Issue	Pages	Revision Description	Prepared By	Reviewed By
3	1	Current	David Rickson	Marc Evans

	Business Management System	VM/FORM/4009
menard		Issue: 03
	Plate Load Test	Issue Date: 23/08/2023
		Page: 1

Contract Name: Poyle

Contract No: 6726

Installation Date: 10.04.2024

Date of Test: 10.04.2024

Test Depth: 0.3

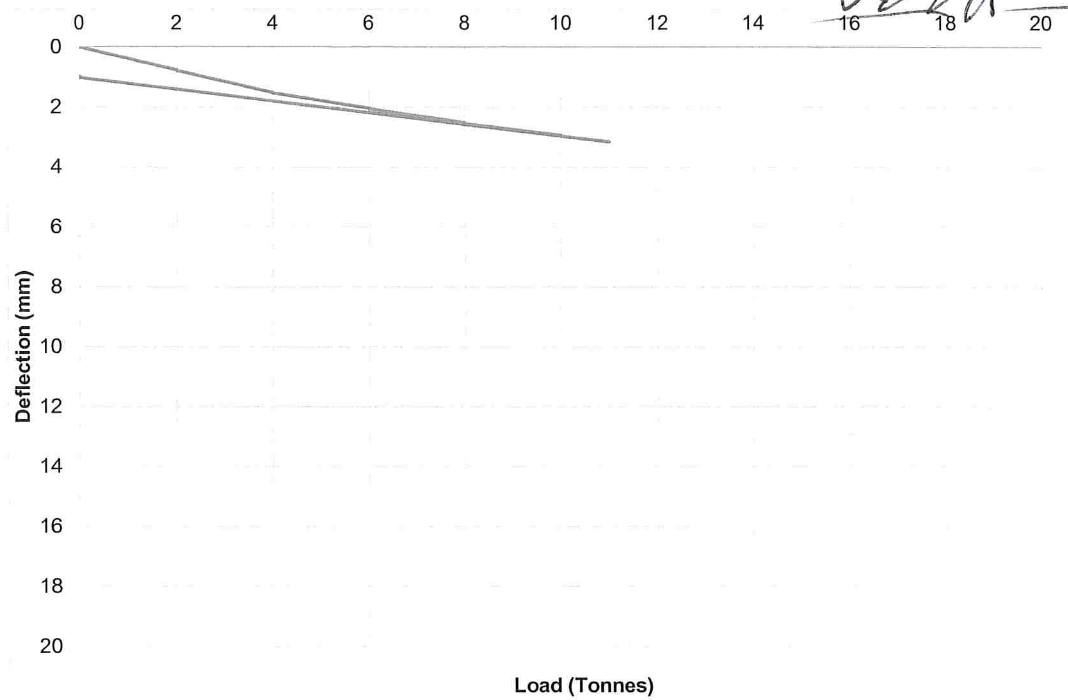
Test Number: 3

Column No: 65

Plate Size: 600mm

Approved By:

Elapsed Time (mins)	Load (tonnes)	Gauge Readings				Gauge Deflections				Average Deflection (mm)
		1	2	3	4	1	2	3	4	
0	0	0	0	0						
1	2	-71	-77	-80		71	77	80		0.76
4	2	-72	-78	-82		72	78	82		0.77
5	2	-73	-79	-83		73	79	83		0.78
6	4	-149	-152	-155		149	152	155		1.52
9	4	-149	-153	-156		149	153	156		1.53
10	4	-150	-154	-156		150	154	156		1.53
11	6	-201	-204	-207		201	204	207		2.04
14	6	-203	-205	-208		203	205	208		2.05
15	6	-204	-206	-209		204	206	209		2.06
16	8	-249	-252	-257		249	252	257		2.53
19	8	-250	-254	-259		250	254	259		2.54
20	8	-251	-255	-261		251	255	261		2.56
21	10	-292	-295	-299		292	295	299		2.95
24	10	-294	-296	-299		294	296	299		2.96
25	10	-295	-297	-301		295	297	301		2.98
26	11	-313	-317	-320		313	317	320		3.17
29	11	-314	-318	-321		314	318	321		3.18
30	11	-314	-318	-321		314	318	321		3.18
0	0	-104	-103	-99		104	103	99		1.02
5	0	-100	-97	-95		100	97	95		0.97



Issue	Pages	Revision Description	Prepared By	Reviewed By
3	1	Current	David Rickson	Marc Evans

menard	Business Management System	VM/FORM/4009
		Issue: 03
	Plate Load Test	Issue Date: 23/08/2023
		Page: 1

Contract Name: Poyle

Contract No: 6726

Installation Date: 10.04.2024

Date of Test: 10.04.2024

Test Depth: 0.3

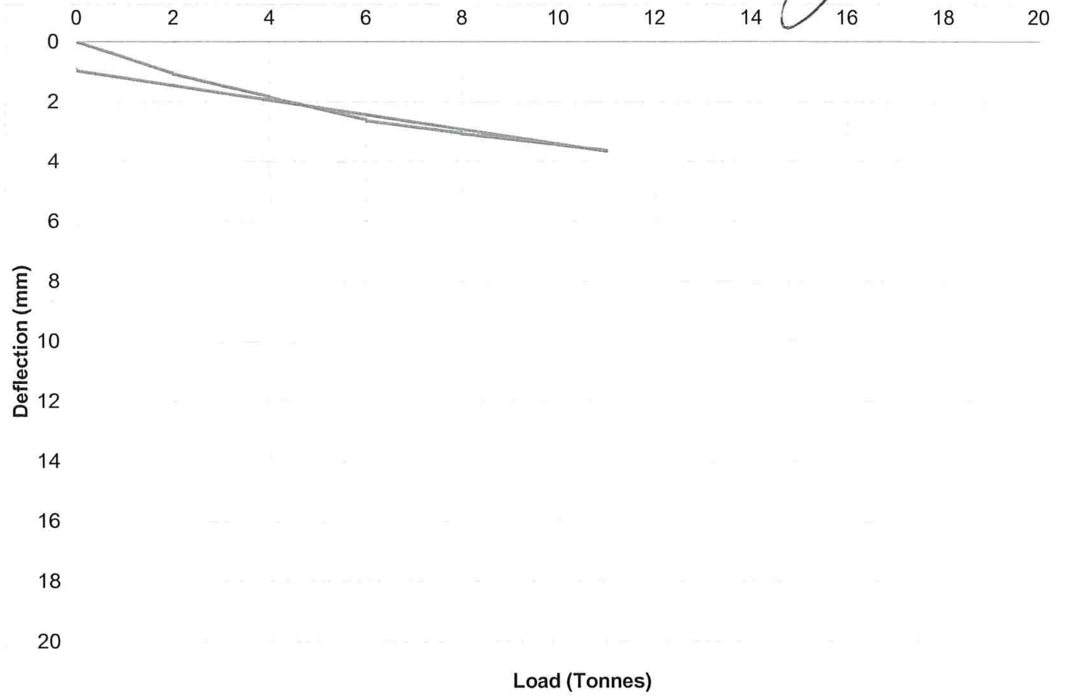
Test Number: 4

Column No: 101

Plate Size: 600mm

Approved By:

Elapsed Time (mins)	Load (tonnes)	Gauge Readings				Gauge Deflections				Average Deflection (mm)
		1	2	3	4	1	2	3	4	
0	0	0	0	0						
1	2	-103	-106	-107		103	106	107		1.05
4	2	-105	-107	-109		105	107	109		1.07
5	2	-106	-108	-110		106	108	110		1.08
6	4	-181	-188	-179		181	188	179		1.83
9	4	-182	-190	-183		182	190	183		1.85
10	4	-183	-191	-183		183	191	183		1.86
11	6	-259	-264	-261		259	264	261		2.61
14	6	-261	-266	-263		261	266	263		2.63
15	6	-262	-267	-264		262	267	264		2.64
16	8	-301	-306	-309		301	306	309		3.05
19	8	-304	-307	-310		304	307	310		3.07
20	8	-305	-308	-310		305	308	310		3.08
21	10	-341	-347	-344		341	347	344		3.44
24	10	-341	-347	-346		341	347	346		3.45
25	10	-342	-347	-346		342	347	346		3.45
26	11	-361	-366	-364		361	366	364		3.64
29	11	-363	-367	-366		363	367	366		3.65
30	11	-364	-368	-367		364	368	367		3.66
0	0	-97	-98	-95		97	98	95		0.97
5	0	-95	-90	-91		95	90	91		0.92



Issue	Pages	Revision Description	Prepared By	Reviewed By
3	1	Current	David Rickson	Marc Evans

menard	Business Management System	VM/FORM/4009 Issue: 03
	Plate Load Test	Issue Date: 23/08/2023 Page: 1

Contract Name: Poyle

Contract No: 6726

Installation Date: 11.04.2024

Date of Test: 15.04.2024

Test Depth: 0.3

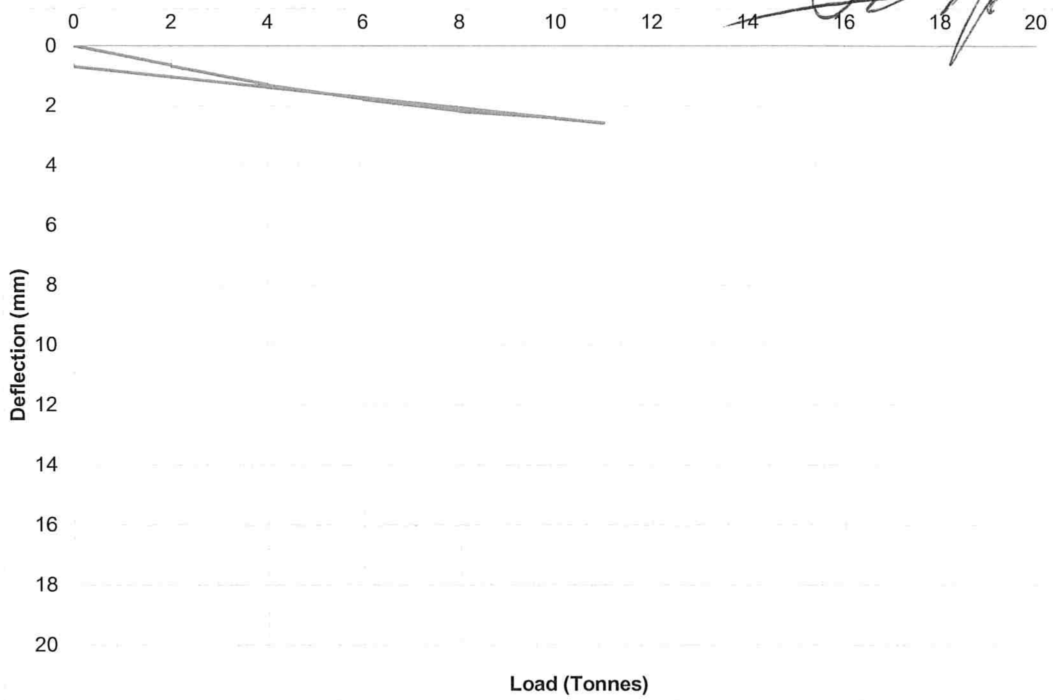
Test Number: 5

Column No: 486

Plate Size: 600mm

Approved By:

Elapsed Time (mins)	Load (tonnes)	Gauge Readings				Gauge Deflections				Average Deflection (mm)
		1	2	3	4	1	2	3	4	
0	0	0	0	0						
1	2	-69	-61	-66		69	61	66		0.65
4	2	-71	-63	-67		71	63	67		0.67
5	2	-72	-64	-68		72	64	68		0.68
6	4	-133	-127	-130		133	127	130		1.30
9	4	-135	-128	-132		135	128	132		1.32
10	4	-135	-129	-133		135	129	133		1.32
11	6	-180	-177	-178		180	177	178		1.78
14	6	-181	-178	-180		181	178	180		1.80
15	6	-182	-178	-180		182	178	180		1.80
16	8	-220	-216	-219		220	216	219		2.18
19	8	-222	-218	-222		222	218	222		2.21
20	8	-223	-218	-222		223	218	222		2.21
21	10	-241	-239	-244		241	239	244		2.41
24	10	-243	-240	-245		243	240	245		2.43
25	10	-244	-241	-246		244	241	246		2.44
26	11	-257	-255	-263		257	255	263		2.58
29	11	-258	-256	-264		258	256	264		2.59
30	11	-259	-256	-264		259	256	264		2.60
0	0	-71	-73	-67		71	73	67		0.70
5	0	-68	-70	-66		68	70	66		0.68



Issue	Pages	Revision Description	Prepared By	Reviewed By
3	1	Current	David Rickson	Marc Evans

menard	Business Management System	VM/FORM/4009
		Issue: 03
	Plate Load Test	Issue Date: 23/08/2023
		Page: 1

Contract Name: Poyle

Installation Date: 11.04.2024

Test Depth: 0.3

Column No: 711

Contract No: 6726

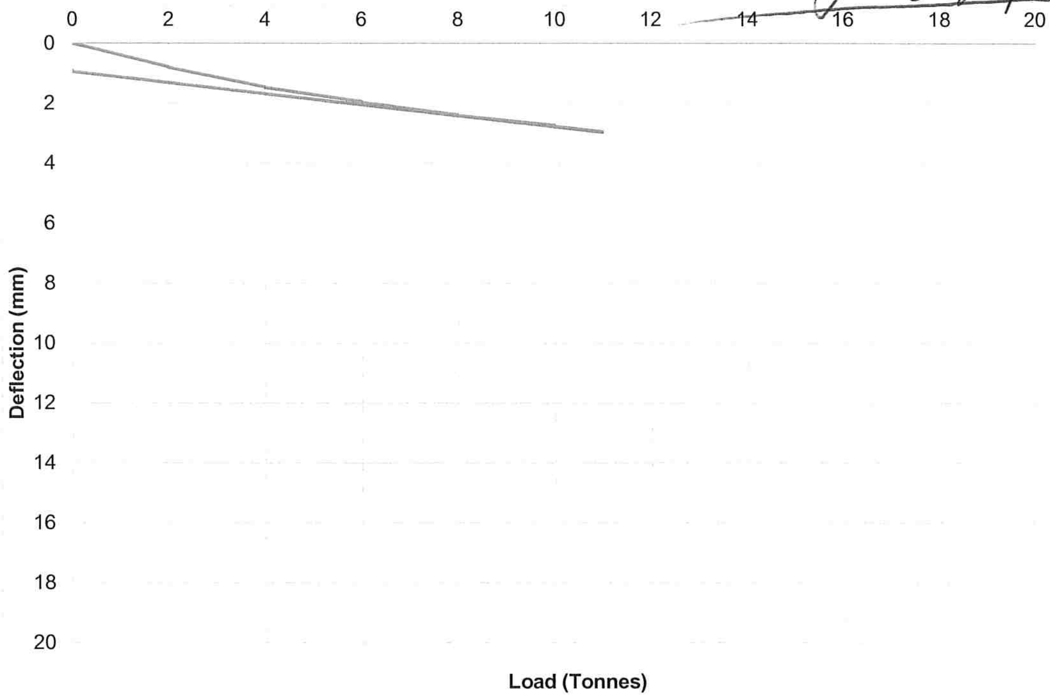
Date of Test: 15.04.2024

Test Number: 6

Plate Size: 600mm

Approved By:

Elapsed Time (mins)	Load (tonnes)	Gauge Readings				Gauge Deflections				Average Deflection (mm)
		1	2	3	4	1	2	3	4	
0	0	0	0	0						
1	2	-74	-80	-83		74	80	83		0.79
4	2	-76	-81	-84		76	81	84		0.80
5	2	-76	-83	-85		76	83	85		0.81
6	4	-141	-146	-150		141	146	150		1.46
9	4	-143	-148	-151		143	148	151		1.47
10	4	-144	-149	-151		144	149	151		1.48
11	6	-191	-195	-199		191	195	199		1.95
14	6	-193	-196	-201		193	196	201		1.97
15	6	-194	-198	-202		194	198	202		1.98
16	8	-235	-240	-244		235	240	244		2.40
19	8	-237	-241	-246		237	241	246		2.41
20	8	-238	-242	-247		238	242	247		2.42
21	10	-271	-275	-279		271	275	279		2.75
24	10	-273	-276	-280		273	276	280		2.76
25	10	-274	-277	-281		274	277	281		2.77
26	11	-293	-295	-300		293	295	300		2.96
29	11	-294	-297	-303		294	297	303		2.98
30	11	-294	-297	-303		294	297	303		2.98
0	0	-91	-94	-98		91	94	98		0.94
5	0	-88	-90	-95		88	90	95		0.91



Issue	Pages	Revision Description	Prepared By	Reviewed By
3	1	Current	David Rickson	Marc Evans

4. As Built Drawings

N/A

5. Testing & Commissioning Results and Certificates

N/A

6. Operation

N/A

7. Maintenance Procedures and Planned Maintenance

N/A

8. Spares Information

N/A

9. Guarantees and Warranties

N/A

winvic

10. Replacement Strategy

N/A

11. Demolition Decommissioning or Disposal

N/A