Foxta v3

# Part K: FONDPROF Module

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# K.1. Introduction

The purpose of the Fondprof module is to calculate the bearing capacity of a single pile in accordance with the french standard in force NF P 94 262. It is also used for calculation in accordance with the former french rules of Fascicle 62 or DTU 13.2 (retained simply for information).

# K.2. Theoretical aspects

The Fondprof module is a calculation programme for predicting the limit load $Q_l$, and the maximum authorised loads under ULS and SLS loadings, based on pressuremeter or penetrometer test results. It is based on the concepts and formulations recommended by the limit state regulations in force in France (currently standard NF P 94 262, which replaces the provisions of Fascicle 62-Title V of the CCTG and those of DTU 13.2). The following chapters specify the methodology adopted for evaluation of the loads, along with the various physical quantities and notations.

As defined in standard NF P 94 262, the calculation procedure applied by Fondprof is comparable to the "**field model**" procedure.

## K.2.1. Bearing capacity limit states

### K.2.1.1. Limit load $Q_l$

We consider a pile with a base situated at depth D in a homogeneous soil (Figure K.1). This pile, the weight of which is ignored, is axially loaded at the pile head by a load Q. At the moment of failure, the load $Q_l$ is balanced by the following soil limit reactions:

- Unit soil resistance under base $q_p$, leading to the base limit load: $Q_p = q_p.A$ with A being the straight section of the base;
- Resistance $q_{sl}$ due to soil friction on the lateral surface of the pile; if $q_s$ is the limit unit shaft friction, the shaft friction limit load is:
  $Q_s = q_s.P.D$ with P the pile drilling perimeter.

And we have: $Q_l = Q_p + Q_s$

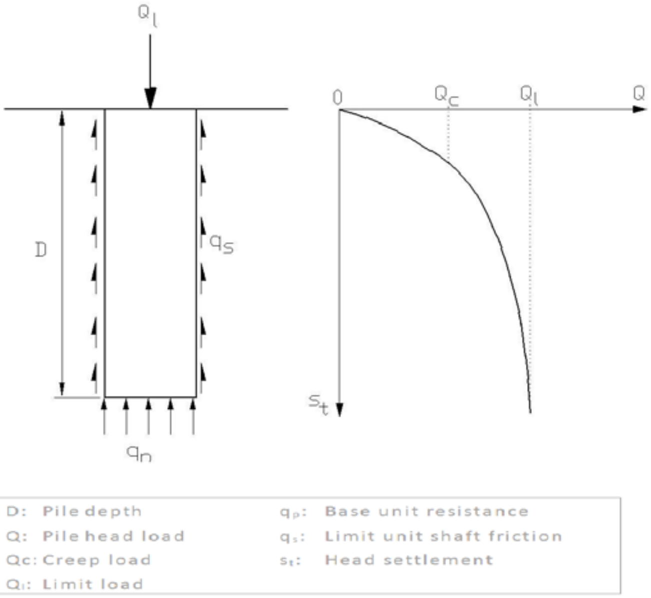



*Figure K.1 : FONDPROF Module – Pile axial loading curve*

### K.2.1.2. Creep load $Q_c$

The curve representing the load applied to the pile according to the settlement has an appreciably linear part limited to load $Q_c$ called the creep load (Figure K.2). For loads higher than $Q_c$, settlement of the pile is no longer stabilised with time, at constant load.

Numerous full-scale pile loading tests carried out by the Ponts et Chaussées laboratories have established correlations between the creep load $Q_c$ and the base limit $Q_p$ and shaft friction $Q_s$ loads. These correlations differ according to the mode of installation of the pile in the soil. The following relations can be established:

- for piles implemented with lateral soil displacement: $Q_c = 0.7Q_s + 0.7Q_p$
- for piles implemented without lateral soil displacement: $Q_c = 0.7Q_s + 0.5Q_p$

The design methods given in the following sections aim to determine the limit load $Q_l$. The creep load $Q_c$ will be deduced from this using empirical formulas, except in the case of the static load test, in which case it can be evaluated directly.

### K.2.2. Pile classification

The following table gives the pile classification applied by Fondprof in accordance with standard NF P 94 262. The piles are classified into 8 classes and 20 categories.

| Class | Category | Implementation technique | Abbreviation | Reference standard |
|---|---|---|---|---|
| 1 | 1 | Bored pile (no support) | FS | NF EN 1536 |
| | 2 | Bored pile with slurry | FB | |
| | 3 | Bored pile (permanent casing) | FTP | |
| | 4 | Bored pile (recoverable casing) | FTR | |
| | 5 | Dry Bored Pile / or Slurry Bored Pile with Grooved /Sockets | FSR, FBR, PU | |
| 2 | 6 | CFA pile | FTC, FTCD | NF EN 1536 |
| 3 | 7 | Screw cast in place pile | VM | NF EN 12699 |
| | 8 | Screw piles with casing | VT | |
| 4 | 9 | Closed-ended driven pile : pre-cast or pre-stressed / concrete | BPF, BPR | NF EN 12699 |
| | 10 | Closed-ended driven piles : coated driven Steel Pile (coating: concrete, mortar, grout) | BE | |
| | 11 | Closed-ended driven piles : driven cast-in-place Pile | BM | |
| | 12 | Closed-ended driven piles : driven steel pile, closed-ended | BAF | |
| 5 | 13 | Driven steel pile, open-ended | BAO | NF EN 12699 |
| 6 | 14 | Driven H piles | HB | NF EN 12699 |
| | 15 | Driven grouted H Pile | HBi | |
| 7 | 16 | Driven sheet pile walls | PP | NF EN 12699 |
| 1bis | 17 | Micropile I (gravity pressure) | M1 | NF EN 1536/14199/12699 |
| | 18 | Micropile II (low pressure) | M2 | |
| 8 | 19 | Micropile III (high pressure) | PIGU, MIGU | |
| | 20 | Micropile IV (high pressure with TAM) | PIRS, MIRS | |

*Table K.1 : Classification of piles (Appendix A – NF P 94 262)*

### K.2.3. Geometry

The pile is characterised geometrically by means of the following parameters:

- Base section noted "A";
- Shaft perimeter noted "P".

B is the base diameter of the pile. In the case of a non-circular section, the value of B is deduced from section A by means of the following formula:

$$B = 2\sqrt{\frac{A}{\pi}}$$

For piles with a non-circular section, the values of A and P are those given in the following figure.

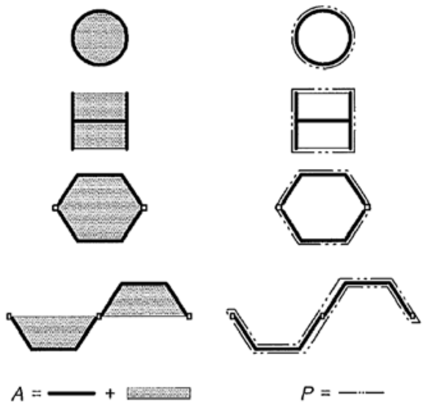



*Figure K.2 : Choice of A and P for a non-circular section*

### K.2.4. Calculation of $q_p$ and $q_s$ from the MPT pressuremeter results

#### K.2.4.1. Base resistance pressure $q_p$

The base resistance pressure of a single pile can be expressed using the following formula:

$$q_p = k_p . p_{le}^*$$

- The equivalent base limit pressure $p_{le}^*$ is obtained with the formula:

$$p_{le}^* = \frac{1}{b+3a}\int_{D-b}^{D+3a} p_l^*(z)dz \quad \text{with} \quad \begin{cases} a = \max\left(\frac{B}{2}, 0.5m\right) \\ b = \min(h, a) \end{cases}$$

  Where "h" is the embedded depth of a pile in the support layer.

- The pressuremeter bearing coefficient $k_p$ is expressed by the following formula:

$$k_p = \min\left(1 + (k_{p\max} - 1)\frac{D_{ef}}{5B}, k_{p\max}\right) \quad \text{with} \quad D_{ef} = \frac{1}{p_{le}^*}\int_{D-10B}^{D} p_l^*(z)dz$$

  $D_{ef}$ is called the equivalent embedment depth. The values of $k_p = k_{pmax}$ for $D_{ef} > 5B$ are specified in the following figure. It should be noted that these values already include the $\rho_p$ reduction coefficients usually applied to open sections.

| Soil / Pile class (c) | Clay % CaCO3 < 30% Silt Intermediate soils | Intermediate soils Sand Gravel | Chalk | Marl and marly limestone | Weathered and fragmented rock (a) |
|---|---|---|---|---|---|
| 1 | 1.15 (b) | 1.1 (b) | 1.45 (b) | 1.45 (b) | 1.45 (b) |
| 2 | 1.3 | 1.65 | 1.6 | 1.6 | 2.0 |
| 3 | 1.55 | 3.2 | 2.35 | 2.10 | 2.10 |
| 4 | 1.35 | 3.1 | 2.30 | 2.30 | 2.30 |
| 5 # | 1.0 | 1.9 | 1.4 | 1.4 | 1.2 |
| 6 # | 1.20 | 3.10 | 1.7 | 2.2 | 1.5 |
| 7 # | 1.0 | 1.0 | 1.0 | 1.0 | 1.2 |
| 8 | 1.15 (b) | 1.1 (b) | 1.45 (b) | 1.45 (b) | 1.45 (b) |

*Table K.2 : Pressuremeter bearing coefficient $k_{pmax}$ for $D_{ef}$ > 5 B (Appendix F - NF P 94 262)*

**Note**: refer to appendix F of standard NF P 94 262 for points (a), (b), (c) and #.

### K.2.4.2. Limit unit shaft friction $q_s$

The limit shaft friction $q_s$ that can be mobilised in a given layer is expressed by means of the following equation:

$$q_s = \min(q_s^{max}, \alpha_{pile\text{-}soil} \times f_{soil})$$

- $q_s^{max}$ designates the maximum friction that can be mobilised for a given soil type and pile category. The values of $q_s^{max}$ are specified in Table K.3. It should be noted that these values already include the $\rho_s$ reduction coefficients usually applied for open sections.
- $\alpha_{pile\text{-}soil}$ is a dimensionless parameter which depends both on the type of pile and the type of soil. Its values are specified in Table K.4.

$f_{soil}$ depends on the intrinsic resistance of the soil, here represented by the limit pressure. The value of $f_{soil}$ is obtained by correlation with the limit pressure according to the curves in Figure K.3.

| N° | Abbreviat° | Technique implementation | Values in kPa | | | | |
|---|---|---|---|---|---|---|---|
| | | | Clay<br>% CaCO3 < 30% Silt<br>Intermediate soils | Intermediate soils<br>Sand Gravel | Chalk | Marl and marly limestone | Weathered and fragmented rock |
| 1 | FS ## | Bored pile (no support) | 90 | 90 | 200 | 170 | 200 |
| 2 | FB ## | Bored pile with slurry | 90 | 90 | 200 | 170 | 200 |
| 3 | FTP | Bored pile (permanent casing) | 50 | 50 | 50 | 90 | ___ |
| 4 | FTR | Bored pile (recoverable casing) | 90 | 90 | 170 | 170 | ___ |
| 5 | FSR, FBR, PU ## | Dry Bored Pile / or Slurry Bored Pile with Grooved /Sockets | 90 | ___ | ___ | ___ | ___ |
| 6 | FTC, FTCD | CFA pile | 90 | 170 | 200 | 200 | 200 |
| 7 | VM | Screw cast in place pile | 130 | 200 | 170 | 170 | ___ |
| 8 | VT | Screw piles with casing | 50 | 90 | 90 | 90 | ___ |
| 9 | BPF**, BPR** | Closed-ended driven pile : pre-cast or pre-stressed / concrete | 130 | 130 | 90 | 90 | ___ |
| 10 | BE** | Closed-ended driven piles : coated driven Steel Pile (coating: concrete, mortar, grout) | 170 | 260 | 200 | 200 | ___ |
| 11 | BM** | Closed-ended driven piles : driven cast-in-place Pile | 90 | 90 | 50 | 90 | ___ |
| 12 | BAF** | Closed-ended driven piles : driven steel pile, closed-ended | 90 | 90 | 50 | 90 | ___ |
| 13 | BAO** # | Driven steel pile, open-ended | 90 | 50 | 50 | 90 | 90 |
| 14 | HB** # | Driven H piles | 90 | 130 | 50 | 90 | 90 |
| 15 | HBi** | Driven grouted H Pile | 200 | 380 | 320 | 320 | 320 |
| 16 | PP** # | Driven sheet pile walls | 90 | 50 | 50 | 90 | 90 |
| 17 | M1 | Micropile I (gravity pressure) | ___ | ___ | ___ | ___ | ___ |
| 18 | M2 | Micropile II (low pressure) | ___ | ___ | ___ | ___ | ___ |
| 19 | PIGU, MIGU | Micropile III (high pressure) | 200 | 380 | 320 | 320 | 320 |
| 20 | PIRS, MIRS | Micropile IV (high pressure with TAM) | 200 | 440 | 440 | 440 | 500 |

*Table K.3 : Values of $q_s^{max}$ – pressuremeter method (Appendix F - NF P 94 262)*

| N° | Abbrev. | Technique implementation | Value in kPa | | | | |
|---|---|---|---|---|---|---|---|
| | | | **Clay**<br>**% CaCO3 < 30% Silt Intermediate soils** | **Intermediate soils**<br>**Sand Gravel** | **Chalk** | **Marl and marly limestone** | **Weathered and fragmented rock** |
| 1 | FS ## | Bored pile (no support) | 1,1 | 1 | 1,8 | 1,5 | 1,6 |
| 2 | FB ## | Bored pile with slurry | 1,25 | 1,4 | 1,8 | 1,5 | 1,6 |
| 3 | FTP | Bored pile (permanent casing) | 0,7 | 0,6 | 0,5 | 0,9 | ___ |
| 4 | FTR | Bored pile (recoverable casing) | 1,25 | 1,4 | 1,7 | 1,4 | ___ |
| 5 | FSR, FBR, PU ## | Dry Bored Pile / or Slurry Bored Pile with Grooved /Sockets | 1,3 | ___ | ___ | ___ | ___ |
| 6 | FTC, FTCD | CFA pile | 1.5 | 1.8 | 2.1 | 1.6 | 1.6 |
| 7 | VM | Screw cast in place pile | 1.9 | 2.1 | 1.7 | 1.7 | ___ |
| 8 | VT | Screw piles with casing | 0.6 | 0.6 | 1 | 0.7 | ___ |
| 9 | BPF**, BPR** | Closed-ended driven pile : pre-cast or pre-stressed / concrete | 1.1 | 1.4 | 1 | 0.9 | ___ |
| 10 | BE** | Closed-ended driven piles : coated driven Steel Pile (coating: concrete, mortar, grout) | 2 | 2.1 | 1.9 | 1.6 | ___ |
| 11 | BM** | Closed-ended driven piles : driven cast-in-place Pile | 1.2 | 1.4 | 2.1 | 1 | ___ |
| 12 | BAF** | Closed-ended driven piles : driven steel pile, closed-ended | 0.8 | 1.2 | 0.4 | 0.9 | ___ |
| 13 | BAO** # | Driven steel pile, open-ended | 1.2 | 0.7 | 0.5 | 1 | 1 |
| 14 | HB** # | Driven H piles | 1.1 | 1 | 0.4 | 1 | 0.9 |
| 15 | HBi** | Driven grouted H Pile | 2.7 | 2.9 | 2.4 | 2.4 | 2.4 |
| 16 | PP** # | Driven sheet | 0.9 | 0.8 | 0.4 | 1.2 | 1.2 |

| N° | Abbrev. | Technique implementation | Value in kPa | | | | |
|---|---|---|---|---|---|---|---|
| | | | Clay<br>% CaCO3 < 30% Silt Intermediate soils | Intermediate soils<br>Sand Gravel | Chalk | Marl and marly limestone | Weathered and fragmented rock |
| | | pile walls | | | | | |
| 17 | M1 | Micropile I (gravity pressure) | —— | —— | —— | —— | —— |
| 18 | M2 | Micropile II (low pressure) | —— | —— | —— | —— | —— |
| 19 | PIGU, MIGU | Micropile III (high pressure) | 2.7 | 2.9 | 2.4 | 2.4 | 2.4 |
| 20 | PIRS, MIRS | Micropile IV (high pressure with TAM) | 3.4 | 3.8 | 3.1 | 3.1 | 3.1 |

*Table K.4 : Values of parameter $\alpha_{pile\text{-}soil}$ - pressuremeter method (Appendix F - NF P 94 262)*

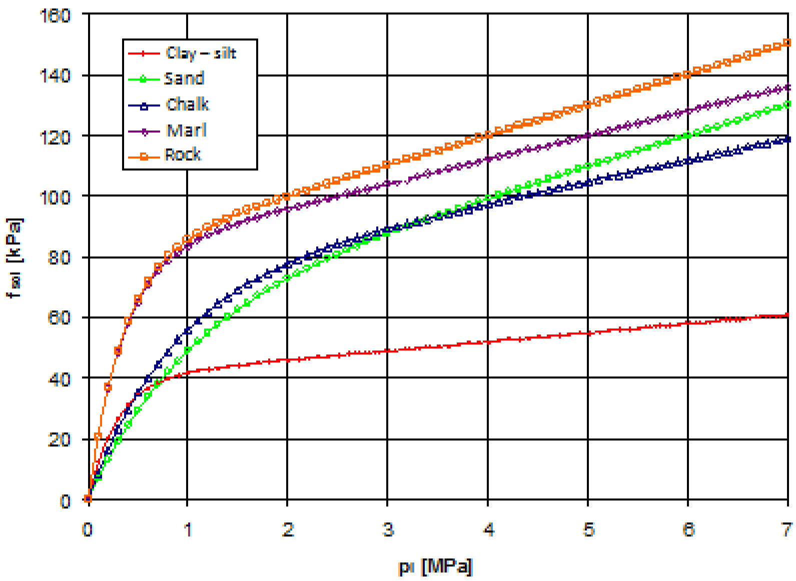



*Figure K.3 : Curves $f_{sol}(p_l)$ - pressuremeter method (Appendix F - NF P 94 262)*

**Note**: refer to Appendix F of standard NF P 94 262 for points (a), (b), (c), # and ##.

### K.2.5. Calculation of $q_p$ and $q_s$ from the results of the CPT static penetrometer

#### K.2.5.1. Base resistance pressure $q_p$

The base resistance pressure of a single pile can be expressed using the following equation:

$$q_p = k_c . q_{ce}$$

- The equivalent resistance pressure $q_{ce}$ is obtained (after smoothing) with the equation:

$$q_{ce} = \frac{1}{b+3a} \int_{D-b}^{D+3a} q_{cc}(z)dz \quad \text{with} \quad \begin{cases} a = \max\left(\frac{B}{2}, 0.5m\right) \\ b = \min(h, a) \end{cases}$$

Where "h" is the embedded depth of the pile in the support layer.

- The penetrometer bearing coefficient $k_c$ is expressed using the equation:

$$k_c = \min\left(k_{c\,min} + \left(k_{c\,max} - k_{c\,min}\right)\frac{D_{ef}}{5B}, k_{c\,max}\right) \quad \text{with} \quad D_{ef} = \frac{1}{q_{ce}} \int_{D-10B}^{D} q_c(z)dz$$

$D_{ef}$ is called the equivalent embedment depth. The bearing coefficient for nil embedment $k_c = k_{cmin}$ is taken as equal to:

  - ✓ 0.30 for a clayey soil;
  - ✓ 0.20 for an intermediate soil;
  - ✓ 0.10 for sand and gravel;
  - ✓ 0.15 for chalk, marl or weathered rock.

The values of $k_c = k_{cmax}$ for $D_{ef}$ > 5 B are specified in the following figure. It should be noted that these values include the $\rho_p$ reduction coefficients usually applied for open sections.

| Soil / Pile class (c) | Clay<br>% CaCO3 < 30%<br>Silt | Intermediate soil | Sand Gravel | Chalk | Marl and marly limestone | Weathered and fragmented rock (a) |
|---|---|---|---|---|---|---|
| 1 | 0.4 (b) | 0.3 (b) | 0.2 (b) | 0.3 (b) | 0.3 (b) | 0.3 (b) |
| 2 | 0.45 | 0.3 | 0.25 | 0.3 | 0.3 | 0.3 |
| 3 | 0.5 | 0.5 | 0.5 | 0.4 | 0.35 | 0.35 |
| 4 | 0.45 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| 5 # | 0.35 | 0.3 | 0.25 | 0.15 | 0.15 | 0.15 |
| 6 # | 0.4 | 0.4 | 0.4 | 0.35 | 0.2 | 0.2 |
| 7 # | 0.35 | 0.25 | 0.15 | 0.15 | 0.15 | 0.15 |
| 8 | 0.45 (b) | 0.3 (b) | 0.2 (b) | 0.3 (b) | 0.3 (b) | 0.25 (b) |

*Table K.5 : Penetrometer bearing coefficient $k_{cmax}$ for $D_{ef}$ > 5 B (Appendix G - NF P 94 262)*

**Note**: refer to Appendix G of standard NF P 94 262 for points (a), (b), (c) and #.

### K.2.5.2. Limit unit shaft friction $q_s$

The limit shaft friction $q_s$ that can be mobilised in a given layer is expressed using the following equation:

$$q_s = \min\left(q_s^{max}, \alpha_{pile\text{-}soil} \times f_{soil}\right)$$

- $q_s^{max}$ designates the maximum friction that can be mobilised for a given soil type and pile category. The values of $q_s^{max}$ are specified in Table K.6. It should be noted that these values include the $\rho_s$ reduction coefficients usually applied for open sections.
- $\alpha_{pile\text{-}soil}$ is a dimensionless parameter which depends on both the type of pile and the type of soil. Its values are specified in Table K.7.
- $f_{soil}$ is a function of the intrinsic soil resistance, here represented by the base pressure $q_c$. The value of $f_{soil}$ is obtained by correlation with $q_c$ according to the curves in Figure K.5.

| N° | Abbreviation | Implementation technique | Clay % $CaCO_3$< 30 % Silt | Intermediate soils | Sand Gravel | Chalk | Marl and Marly limestone | Weathered or fragmented rock |
|---|---|---|---|---|---|---|---|---|

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | FS ## | Bored pile (no support) | 90 | 90 | 90 | 200 | 170 | 200 |
| 2 | FB ## | Bored pile with slurry | 90 | 90 | 90 | 200 | 170 | 200 |
| 3 | FTP | Bored pile (permanent casing) | 50 | 50 | 50 | 50 | 90 | ___ |
| 4 | FTR | Bored pile (recoverable casing) | 90 | 90 | 90 | 170 | 170 | ___ |
| 5 | FSR, FBR, PU ## | Dry Bored Pile / or Slurry Bored Pile with Grooved /Sockets | 90 | 90 | ___ | ___ | ___ | ___ |
| 6 | FTC, FTCD | CFA pile | 90 | 90 | 170 | 200 | 200 | 200 |
| 7 | VM | Screw cast in place pile | 130 | 130 | 200 | 170 | 170 | ___ |
| 8 | VT | Screw piles with casing | 50 | 50 | 90 | 90 | 90 | ___ |
| 9 | BPF**, BPR** | Closed-ended driven pile : pre-cast or pre-stressed / concrete | 130 | 130 | 130 | 90 | 90 | ___ |
| 10 | BE** | Closed-ended driven piles : coated driven Steel Pile (coating: concrete, mortar, grout) | 170 | 170 | 260 | 200 | 200 | ___ |
| 11 | BM** | Closed-ended driven piles : driven cast-in-place Pile | 90 | 90 | 130 | 260 | 200 | ___ |
| 12 | BAF** | Closed-ended driven piles : driven steel pile, closed-ended | 90 | 90 | 90 | 50 | 90 | ___ |
| 13 | BAO** # | Driven steel pile, open-ended | 90 | 90 | 50 | 50 | 90 | 90 |
| 14 | HB** # | Driven H piles | 90 | 90 | 130 | 50 | 90 | 90 |
| 15 | HBi** | Driven grouted H Pile | 200 | 200 | 380 | 320 | 320 | 320 |
| 16 | PP** # | Driven sheet pile walls | 90 | 90 | 50 | 50 | 90 | 90 |
| 17 | M1 | Micropile I (gravity pressure) | ___ | ___ | ___ | ___ | ___ | ___ |
| 18 | M2 | Micropile II (low pressure) | ___ | ___ | ___ | ___ | ___ | ___ |
| 19 | PIGU, MIGU | Micropile III (high pressure) | 200 | 200 | 380 | 320 | 320 | 320 |
| 20 | PIRS, MIRS | Micropile IV (high pressure with TAM) | 200 | 200 | 440 | 440 | 440 | 500 |

*Table K.6 : Values of $q_s^{max}$ – penetrometer method (Appendix G - NF P 94 262)*

| N° | Abbrev. | Implementation technique | Clay % $CaCO_3$< 30 % Silt | Intermediate soils | Sand Gravel | Chalk | Marl and Marly limestone | Weathered or fragmented rock |
|---|---|---|---|---|---|---|---|---|
| 1 | FS ## | Bored pile (no support) | 0.65 | 0.65 | 0.70 | 0.80 | 1.40 | 1.50 |
| 2 | FB ## | Bored pile with slurry | 0.65 | 0.80 | 1.00 | 0.80 | 1.40 | 1.50 |
| 3 | FTP | Bored pile (permanent casing) | 0.35 | 0.40 | 0.40 | 0.25 | 0.85 | ___ |
| 4 | FTR | Bored pile (recoverable casing) | 0.65 | 0.80 | 1.00 | 0.75 | 0.13 | ___ |
| 5 | FSR, FBR, PU ## | Dry Bored Pile / or Slurry Bored Pile with Grooved /Sockets | 0.70 | 0.85 | ___ | ___ | ___ | ___ |
| 6 | FTC, FTCD | CFA pile | 0.75 | 0.90 | 1.25 | 0.95 | 1.50 | 1.50 |
| 7 | VM | Screw cast in place pile | 0.95 | 1.15 | 1.45 | 0.75 | 1.60 | ___ |
| 8 | VT | Screw piles with casing | 0.30 | 0.35 | 0.40 | 0.45 | 0.65 | ___ |
| 9 | BPF**, BPR** | Closed-ended driven pile : pre-cast or pre-stressed / concrete | 0.55 | 0.65 | 1.00 | 0.45 | 0.85 | ___ |
| 10 | BE** | Closed-ended driven piles : coated driven Steel Pile (coating: concrete, mortar, grout) | 1.00 | 1.20 | 1.45 | 0.85 | 1.50 | ___ |
| 11 | BM** | Closed-ended driven piles : driven cast-in-place Pile | 0.60 | 0.70 | 1.00 | 0.95 | 0.95 | ___ |
| 12 | BAF** | Closed-ended driven piles : driven steel pile, closed-ended | 0.40 | 0.50 | 0.85 | 0.20 | 0.85 | ___ |
| 13 | BAO** # | Driven steel pile, open-ended | 0.60 | 0.70 | 0.50 | 0.25 | 0.95 | 0.95 |
| 14 | HB** # | Driven H piles | 0.55 | 0.65 | 0.70 | 0.20 | 0.95 | 0.85 |
| 15 | HBi** | Driven grouted H Pile | 1.35 | 1.60 | 1.00 | 1.10 | 2.25 | 2.25 |
| 16 | PP** # | Driven sheet pile walls | 0.45 | 0.55 | 0.55 | 0.20 | 1.25 | 1.15 |
| 17 | M1 | Micropile I (gravity pressure) | ___ | ___ | ___ | ___ | ___ | ___ |
| 18 | M2 | Micropile II (low pressure) | ___ | ___ | ___ | ___ | ___ | ___ |
| 19 | PIGU, MIGU | Micropile III (high pressure) | 1.3 | 1.60 | 2.00 | 1.10 | 2.25 | 2.25 |
| 20 | PIRS, MIRS | Micropile IV (high pressure with TAM) | 1.70 | 2.05 | 2.65 | 1.40 | 2.90 | 2.90 |

*Table K.7 : Values of parameter $\alpha_{pile\text{-}soil}$ - penetrometer method (Appendix G - NF P 94 262)*

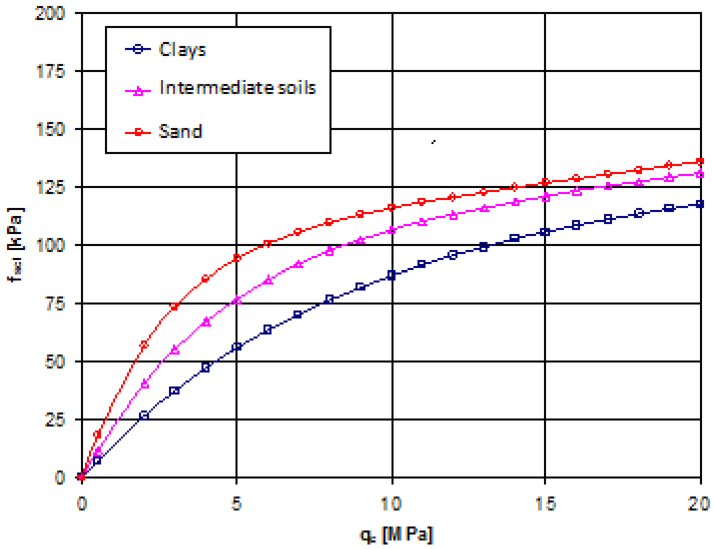



*Figure K.4 : Curves $f_{sol}(q_c)$ – penetrometer method (Appendix G - NF P 94 262)*

**Note**: refer to Appendix G of standard NF P 94 262 for points (*), (**), # and ##.

### K.2.6. SLS / ULS bearing capacity

#### K.2.6.1. Formulation

The calculation value for the bearing capacity of a single pile at SLS or ULS (with regard to the soil resistance mobilisation limit states) is estimated using the following equation:

$$Q_d = \frac{1}{F_{qs}} P.\int_0^D q_s(z)dz + \frac{1}{F_{qp}} A.q_p$$

Where:

- $F_{qs}$: "combined" safety factor applied to limit shaft friction;
- $F_{qp}$: "combined" safety factor applied to base resistance pressure.

  The values of $F_{qs}$ and $F_{qp}$ are obtained by combining several partial coefficients:

  $F_{qs} = (\gamma_{Rd1} \times \gamma_{Rd2} \times \gamma_s) / \beta_1$ $\qquad$ $F_{qp} = (\gamma_{Rd1} \times \gamma_{Rd2} \times \gamma_b) / \beta_2$

- The partial coefficients of model $\gamma_{Rd1}$ and $\gamma_{Rd2}$ are dependent both on the pile category and the calculation method considered (pressuremeter or penetrometer);
- The partial pressure coefficients $\gamma_b$ (base) and $\gamma_s$ (friction) depend on the loading mode (compression/traction) and the combination of actions (permanent or characteristic SLS, fundamental or accidental ULS) considered;
- The correlation parameters (for the creep load) $\beta_1$ and $\beta_2$ are taken as equal to:
  - ✓ $\beta_1 = \beta_2 = 1.0$ at ULS;
  - ✓ $\beta_1 = \beta_2 = 0.7$ at SLS for piles with lateral soil displacement;
  - ✓ $\beta_1 = 0.7$ and $\beta_2 = 0.5$ at SLS for piles without lateral soil displacement.

The values of $q_s(z)$ and $q_p$ are obtained according to the approach described in chapters K.2.4 and K.2.5.

### K.2.6.2. Case of a pile working in compression

The values of $F_{qs}$ and $F_{qp}$ for a pile working in compression are summarised in the following table (PMT = pressuremeter, CPT = penetrometer).

| | Category | Method | Embedded in chalk | SLS QP | SLS CARAC | ULS FOND | ULS ACC |
|---|---|---|---|---|---|---|---|
| **Combined safety factor on Qs** | 1 to 9, 11 to 14 and 16 | PMT | NO | 1.99 | 1.63 | 1.39 | 1.26 |
| | | | YES | 2.42 | 1.98 | 1.69 | 1.54 |
| | | CPT | NO | 2.04 | 1.67 | 1.43 | 1.30 |
| | | | YES | 2.51 | 2.05 | 1.75 | 1.59 |
| | 10, 15 and 17 to 20 | -- | -- | 3.46 | 2.82 | 2.42 | 2.20 |
| **Combined safety factor on Qp** | 1 to 6 | PMT | NO | 2.79 | 2.28 | 1.39 | 1.26 |
| | | | YES | 3.39 | 2.77 | 1.69 | 1.54 |
| | | CPT | NO | 2.86 | 2.34 | 1.43 | 4.30 |
| | | | YES | 3.51 | 2.87 | 1.75 | 1.59 |
| | 7 to 9, 11 to 14 and 16 | PMT | NO | 1.99 | 1.63 | 1.39 | 1.26 |
| | | | YES | 2.42 | 1.98 | 1.69 | 1.54 |
| | | CPT | NO | 2.04 | 1.67 | 1.43 | 1.30 |
| | | | YES | 2.51 | 2.05 | 1.75 | 1.59 |
| | 10 and 15 | -- | -- | 3.46 | 2.82 | 2.42 | 2.20 |
| | 17 to 20 | -- | -- | -- | -- | -- | -- |

*Table K.8 : Values of $F_{qs}$ and $F_{qp}$ for a pile working in compression*

### K.2.6.3. Case of a pile working in traction

The values of $F_{qs}$ and $F_{qp}$ for a pile working in traction are summarised in the following table (PMT = pressuremeter, CPT = penetrometer).

| | Category | Method | Embedded in chalk | SLS QP | SLS CARAC | ULS FOND | ULS ACC |
|---|---|---|---|---|---|---|---|
| **Combined safety factor on Qs** | 1 to 9, 11 to 14 and 16 | PMT | NO | 3.30 | 2.42 | 1.77 | 1.62 |
| | | | YES | 4.00 | 2.94 | 2.15 | 1.96 |
| | | CPT | NO | 3.41 | 2.51 | 1.83 | 1.68 |
| | | | YES | 4.13 | 3.02 | 2.21 | 2.01 |
| | 10, 15 and 17 to 20 | | -- | 4.72 | 3.46 | 2.53 | 2.31 |

*Table K.9 : Values of $F_{qs}$ and $F_{qp}$ for a pile working in traction*

# K.3. User's Guide

This chapter presents the parameters necessary for carrying out a Fondprof calculation, along with the results provided by this module.

The Fondprof module window comprises 3 tabs. All the tabs are visible.

To run a Fondprof calculation, a number of parameters must be input and are specified as and when (certain input zones can only receive data with a physical meaning).

This chapter does not describe the actual user interface and its operations (buttons, menus, etc.): these aspects are dealt with in part C of the manual.

## K.3.1. Management of piles

The Fondprof module is used to process one or more piles for a given Foxta project, but the user can only work on one of these piles at time: the number of the "active" pile is displayed above the tabs in the data input window.

- The first time the Fondprof module is opened for a given project, the module comprises a single pile (Pile 1/1). The user must thus fill out this first pile and can then create additional piles if necessary (see below).
- When a Fondprof module already filled out is opened, the default pile displayed is pile 1/n (n being the total number of piles already created in the module). It is then possible to select another pile, add, or delete piles.

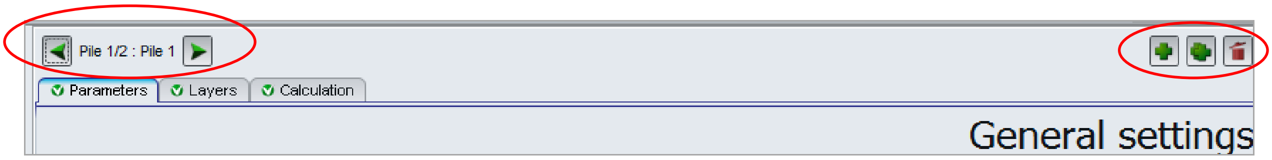



*Figure K.5 : Management of piles in the Fondprof module*

The possible operations on the piles in the Fondprof module are as follows:

- Add a pile: click the button: Foxta adds a new blank pile to the project, independently of the previous one, with the same input fields. Its number will be automatically incremented.
- Duplication of current pile: click the button: Foxta adds to the project a pile that is identical to the current pile. The data are duplicated into this new pile but remain modifiable.
- Delete current pile: click the button.
- Move to next or previous pile: click the or button.

As previously mentioned, it is only possible to "work" on one pile at a time: the user therefore selects the required pile, completes/modifies its data, starts the calculation and then displays the results for this pile. The user can then select another existing pile or create a pile and repeat these operations.

The next chapters describe how to use Fondprof for a given pile.

## K.3.2. "Parameters" tab

This first tab comprises three distinct frames.

These contain input fields which differ according to:

- the choice of the "Regulatory framework" in the "Calculation context" frame;
- the type of calculation section chosen in the "Pile geometry" frame;
- the pile class selected in the "Weighting system" frame.

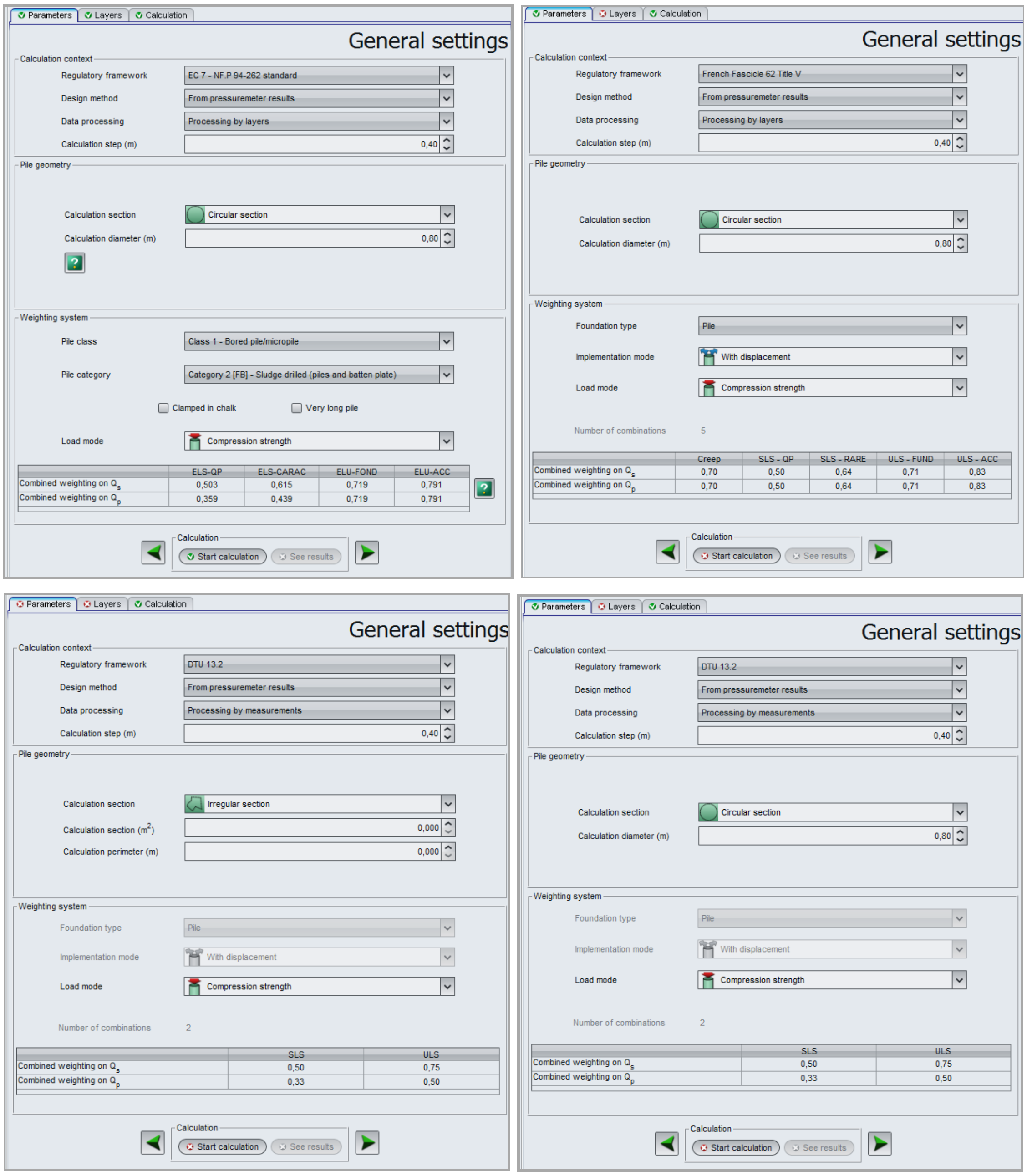



*Figure K.6 : "Parameters" tab – Examples of input zones*

### K.3.2.1. "Calculation context" frame

#### K.3.2.1.1. Data to be defined in this frame

This frame is used to define

- the regulatory framework. The possible choices are:
    - EC7 – Standard NF.P 94-262 (default choice proposed);
    - Fascicle 62;
    - DTU 13.2;
    - "Free" calculation.
- the design method. The possible choices are:
    - from pressuremeter results (default choice proposed);
    - from penetrometer results.
- the data processing:
    - by layers (default choice proposed);
    - by measurements.
- the calculation step (m): the default value proposed is equal to 0.5 m.

#### K.3.2.1.2. Data processing by layers / measurements

Processing by layers enables a single average limit pressure value to be input per layer. This processing is suited to the case of a geotechnical model pre-defined by the user. In this case, the limit pressure value is considered to be uniform over the height of the layer (see example below / illustration of the case of a calculation step of 1 m).

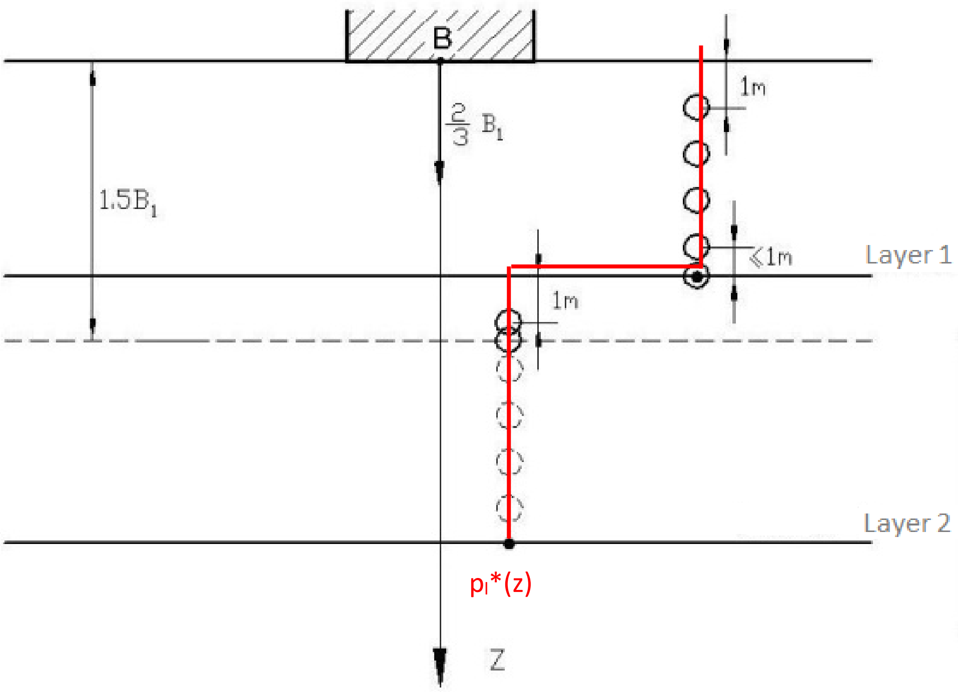



*Figure K.7 : Principle of data processing by layers*

In the case of processing by measurements, the limit pressure is obtained by interpolation between each measurement input. This method is suitable when regular and sufficiently close measurements are available to enable a realistic curve versus depth to be obtained (measurements every metre for example).

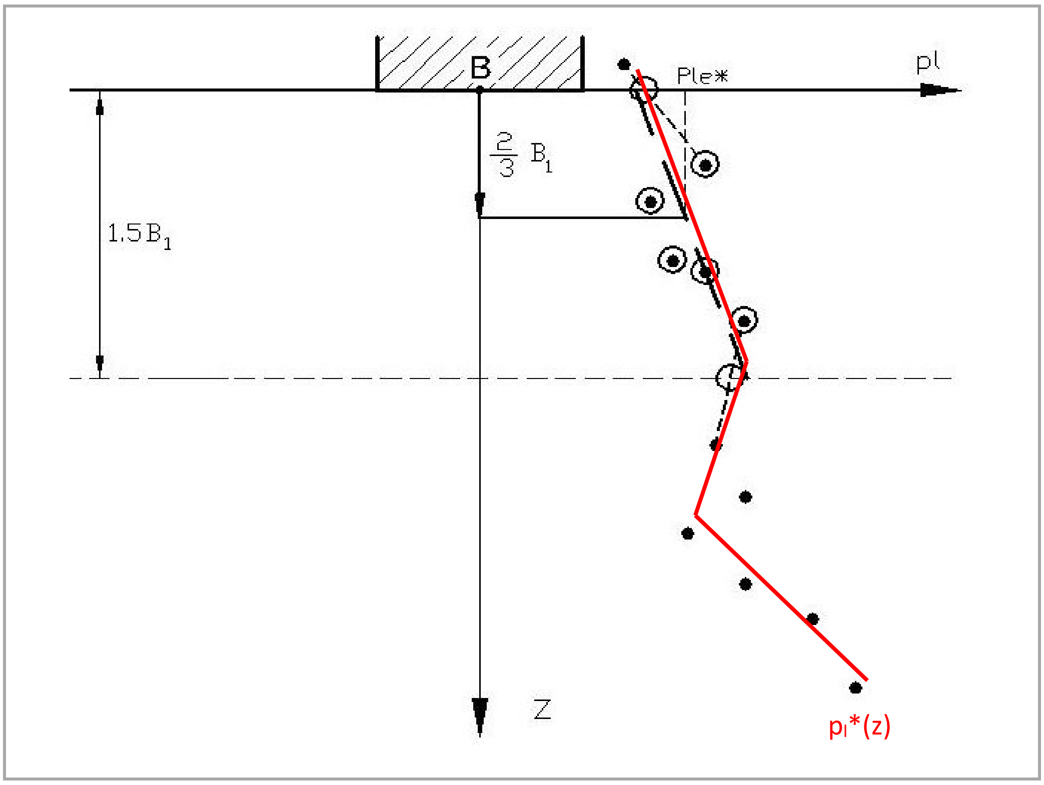



*Figure K.8 : Principle of data processing by measurements*

Processing by measurements should not be used simply by entering an average value per layer: the limit pressure values are then interpolated between only two measurements over the height of the layer and the profile obtained is not realistic.

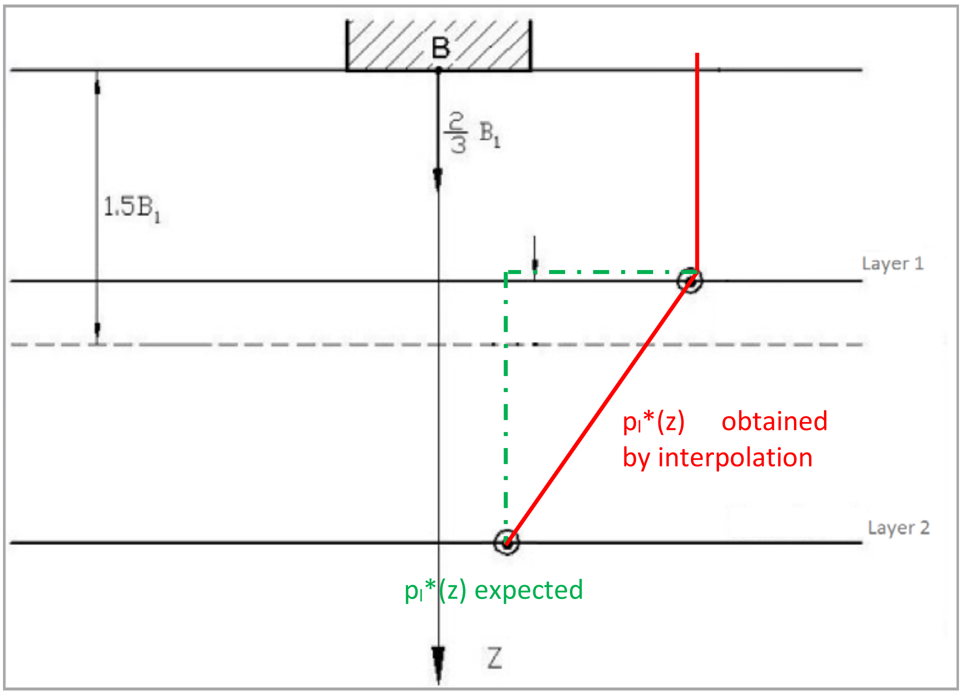



*Figure K.9 : Prohibited use of processing by measurements in the case of average values per layer*

### K.3.2.2. "Pile geometry" frame

This frame is used to define the type of calculation section: irregular or circular.

Depending on the choice, the following data to be input vary:

| Type of calculation section | Calculation section (m²) | Calculation perimeter (m) | Calculation diameter (m) |
|---|---|---|---|
| Irregular | Yes | Yes | No |
| Circular | No | No | Yes |

*Figure K.10 : Pile geometry: data to be input*

A help diagram is available: click the ? button, only if EC7 was selected in the "Regulatory framework" field of the "Calculation context" frame:

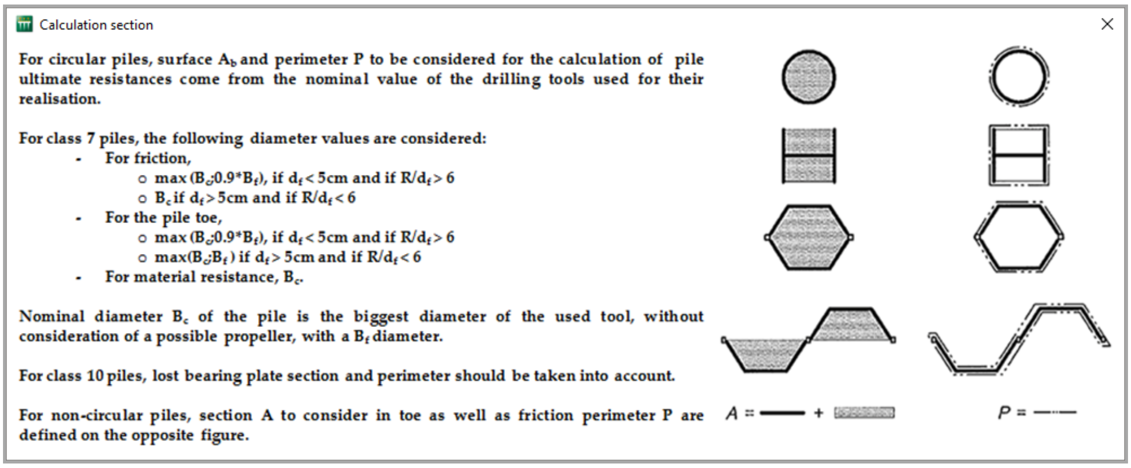



*Figure K.11 : Help diagram: Calculation section*

### K.3.2.3. "Weighting system" frame

The display in this frame varies according to the regulatory framework selected.

#### K.3.2.3.1. EC7 Regulatory framework – Standard NF.P 94-262

The following fields are displayed:

- the pile class (the various possible choices are listed in the table below);
- the pile category (the various possible choices are listed in the table below);
- the loading mode. The possible choices are "Compression strength" (proposed by default) and "Tensile strength".

Two contextual tick boxes appear:

- Embedded in chalk (unticked by default): this is a "global" choice which affects all the weighting coefficients (see technical notice, Table K.8 and Table K.9);
- very long pile (unticked by default): this concerns the class 1 piles longer than 25 m. When this box is ticked, Fondprof automatically applies a 50% reduction on the friction of the sections situated more than 25 m above the base.

The display conditions for these 2 tick boxes are as follows:

| Pile class | Pile category | Embedded in chalk | Very long pile |
|---|---|---|---|
| 1 – Drilled pile/micro-pile | 1 - [FS] – Bored pile (no support) | Yes | Yes |
| | 2 - [FB] – Bored pile with slurry | Yes | Yes |
| | 3 - [FTP] – Bored pile (permanent casing) | Yes | No |
| | 4 - [FTR] – Bored pile (recoverable casing) | Yes | No |
| | 5 - [FSR, FBR, PU] – Simple bored or sludge drilled with slotting or well | Yes | Yes |
| | 17 - [M1] – Micropile I (gravity pressure) | No | No |
| | 18 - [M2] – Micropile II (low pressure) | No | No |
| 2 – Hollow flight auger pile | 6 - [FTC, FTCD] – FA pile | Yes | No |
| 3 – Screw pile | 7 - [VM] – Screw cast in place pile | Yes | No |
| | 8 - [VT] – Screw piles with casing | Yes | No |
| 4 – Driven close-ended pile | 9 - [BPF, BPR] – Closed-ended driven pile : pre-cast or pre-stressed / concrete | Yes | No |
| | 10 - [BE] – Closed-ended driven piles : coated driven Steel Pile (coating: concrete, mortar, grout) | No | No |
| | 11 - [BM] – Closed-ended driven piles : driven cast-in-place Pile | Yes | No |
| | 12 - [BAF] – Closed-ended driven piles : driven steel pile, closed-ended | Yes | No |
| 5 – Open-ended driven pile | 13 - [BAO] – Driven steel pile, open-ended | Yes | No |
| 6 – H-section | 14 - [HB] – Driven H piles | Yes | No |
| | 15 - [HBi] – Driven grouted H Pile | No | No |
| 7 - Sheet piles beaten | 16 - [PP] – Driven sheet pile walls | Yes | No |
| 8 – Grouted pile/micro-pile | 19 - [PIGU, MIGU] – Micropile III (high pressure) | No | No |
| | 20 - [PIRS, MIRS] – Micropile IV (high pressure with TAM) | No | No |

*Table K.10 : Fields of the "Weighting system" frame: display conditions*

A table then displays the combined weightings on $Q_s$ and $Q_p$ for the 4 load combinations: SLS-QP, SLS-CARAC, ULS-FOND and ULS-ACC. The values of these combined weightings are updated at each change in the above data.

A help diagram is available: click the "Weighting details" button to the right of the table.

This displays the values of the various coefficients defined by standard NF.P 94-262 according to the pile class, its category, its embedment in chalk or otherwise and the loading mode.

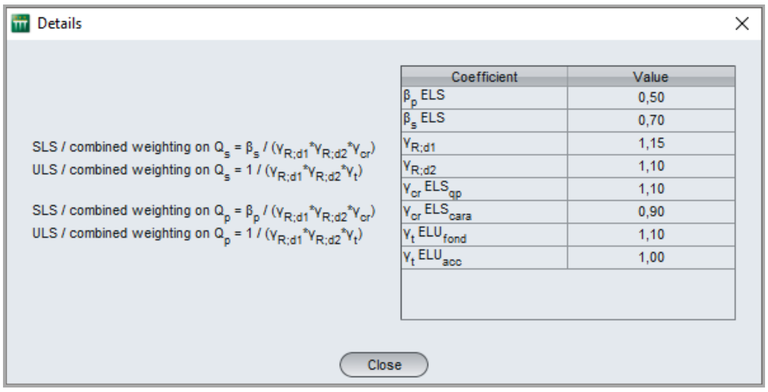



*Figure K.12 : EC7 – Standard NF.P 94-262: Weighting details*

### K.3.2.3.2. Other calculation frames

Fondprof displays the following, which may or may not be shaded:

- foundation type: pile or micro-pile (the "micro-pile" choice is only available in the case of Fascicle 62);
- implementation mode: the pile's ability to laterally displace or not the soil (this choice is only actually available in the case of Fascicle 62);
- load mode: tensile or compression strength (this choice is only actually available in the case of Fascicle 62 and DTU 13.2);
- number of combinations: only modifiable in the case of a "free" calculation. In the case of Fascicle 62, the number of combinations is set at 5 and it is equal to 2 for DTU 13.2.

Fondprof displays the combined weightings on $Q_s$ and on $Q_p$ in a table at the bottom of this frame. The number and title of the columns which are displayed vary according to the regulatory framework chosen and the corresponding combinations.

<u>Display conditions</u>:

| | **Creep** | **SLS QP** | **SLS-RARE** | **ULS-FOND** | **ULS-ACC** | **SLS** | **ULS** | **Coeff i** |
|---|---|---|---|---|---|---|---|---|
| **Fascicle 62** | Yes | Yes | Yes | Yes | Yes | No | No | No |
| **DTU 13.2** | No | No | No | No | No | Yes | Yes | No |
| **Free calculation** | No | No | No | No | No | No | No | Yes |

*Table K.11 : Combined weightings $Q_s$ – $Q_p$*

### K.3.3. "Layers" tab

This second tab is used to define the parameters concerning the behaviour of the soil. The number and type of columns vary according to the regulatory framework and the calculation method input into the "Parameters" tab.

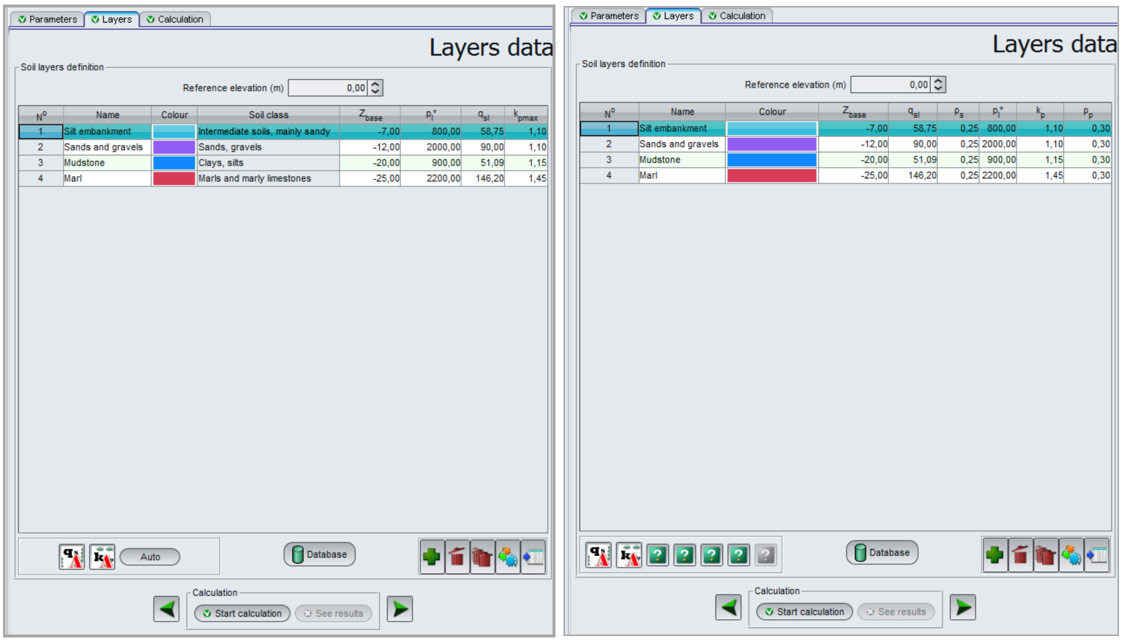



*Figure K.13 : "Layers" tab – Examples of input tables*

#### K.3.3.1. "Soil layers definition" frame

First of all, one must define the reference elevation, in metres: the default value proposed is 0.0 m.

The proposed table must then be filled out.

The following table describes the soil parameters to be defined for each layer:

| Name | Unit | Default value | Display condition | Mandatory value | Local checks |
|---|---|---|---|---|---|
| **Name** of the layer | - | "Layer i" | Always | Yes | - |
| **Colour** of the layer | - | Default colour | Always | Yes | - |
| Soil class | - | "Clay, Silts" | EC7 only (see following table) | Yes | - |
| **$Z_{base}$**: elevation of base of layer | m | 1 m below elev. of base of layer above | Always | Yes | Strictly descending values |
| **$P_l$***: Net limit pressure of layer | kPa | 0,0 | "From pressuremeter results" | Yes | ≠ 0 |
| **$q_{sl}$**: Unit limit shaft friction in the layer | kPa | 1,0 | Always | Yes | ≠ 0 |

| Name | Unit | Default value | Display condition | Mandatory value | Local checks |
|---|---|---|---|---|---|
| **$k_{pmax}$:** Pressuremeter maximum bearing factor | - | 1,0 | EC7 + "From pressuremeter results" | Yes | > 0 |
| **$q_c$:** Base resistance from penetrometer | kPa | 0,0 | "From penetrometer results" | Yes | ≠ 0 |
| **$k_{cmin}$**: Penetrometer minimum bearing factor | - | - | EC7 + "From penetrometer results" | Yes | > 0 |
| **$k_{cmax}$**: Penetrometer maximum bearing factor | - | - | EC7 + "From penetrometer results" | Yes | > 0 |
| **$\rho_s$:** Shaft friction reduction coefficient | - | 1,0 | All except EC7 | Yes | > 0 |
| **$k_p$:** Pressuremeter bearing factor | - | 1,0 | All except EC7 and "From pressuremeter results" | Yes | > 0 |
| **$k_c$:** Penetrometer bearing factor | - | 1,0 | All except EC7 and "From penetrometer results" | Yes | > 0 |
| **$\rho_p$:** Base resistance reduction coefficient | - | 1,0 | All except EC7 | Yes | > 0 |

*Table K.12 : Soil layers data*

In the regulatory frameworks other than EC7, the $\rho_p$ and $\rho_s$ reduction coefficients can be used to take account of varied geometries (H-sections, sheet piles, etc.).

In the case of regulatory framework EC7, the soil classes display conditions are as follows (distinction on the "intermediate" soils):

| Soil class | From pressuremeter results | From penetrometer results |
|---|---|---|
| Clays Silts | Yes | Yes |
| Intermediate soils | No | Yes |
| Intermediate soils, mainly clayey | Yes | No |
| Intermediate soils, mainly sandy | Yes | No |
| Sands, gravels | Yes | Yes |
| Chalk | Yes | Yes |
| Marl and marly limestone | Yes | Yes |
| Weathered and fragmented rock | Yes | Yes |

*Table K.13 : Soil classes display conditions (regulatory framework EC7)*

## K.3.3.2. Help diagrams and wizards

### K.3.3.2.1. Wizards for EC7 projects

**<u>From pressuremeter results</u>:**

The values of $q_{sl}$ and $k_{pmax}$ can be input manually or determined using the corresponding wizards, accessible at the bottom of the "soil layers definition" frame.

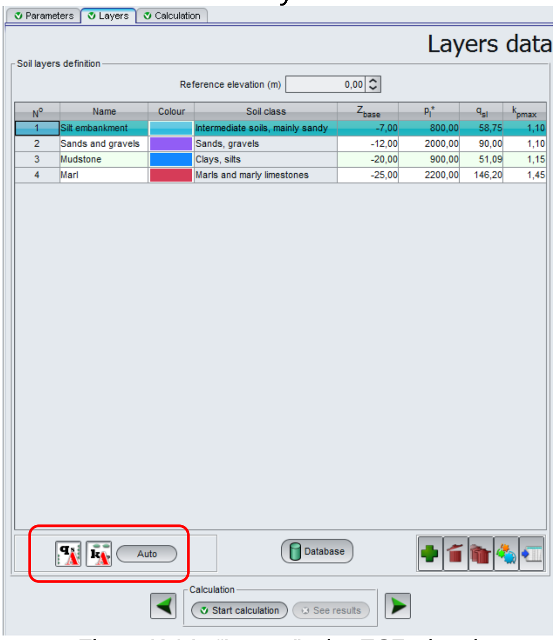



*Figure K.14 : "Layers" tab - EC7 wizards*

<u>Limit unit shaft friction $q_{sl}$</u>:

Select the soil layer concerned, then click the  button to open the wizard.


*Figure K.15 : Wizard $q_{sl}$ – EC7 – From pressuremeter results*

- "Data" frame

  The wizard uses the data previously input for the layer selected (soil type, value of $p_l$*) as well as the pile category chosen. If the layer data have not yet been filled out, it is possible to input them into the wizard.

- "Details" frame

  The $\alpha_{pile\text{-}soil}$ parameter and the values of a, b and c are automatically calculated according to the data input into the "Data" frame and are displayed here.

- "Information" frame

  As applicable, additional information needed to determine $q_{sl}$ are detailed.

- Graph

  The graph shows the $q_{sl}$ versus $p_l$* curve. The red curve shows the value of $q_{sl}$ obtained for the input value of $p_l$*.

- "Results" frame

  When the parameters proposed are appropriate, clicking the Send button enables the $q_{sl}$ value to be sent to the layers definition table for the soil layer selected.

Click the Close button and repeat the operation for each soil layer.

<u>Pressuremeter bearing factor $k_{pmax}$</u>:

Select a soil layer then click the button to open the wizard.

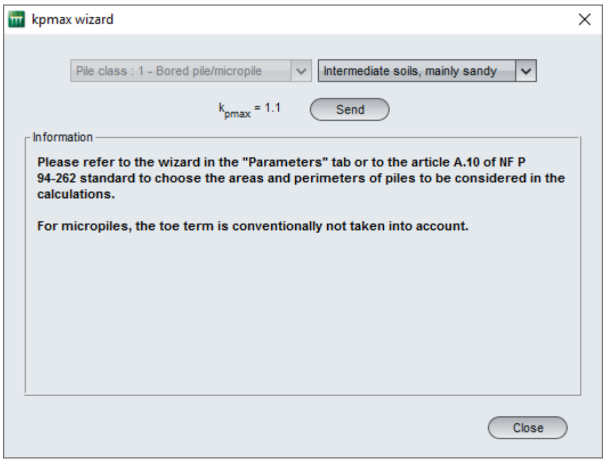



*Figure K.16 : Wizard $k_{pmax}$ – EC7*

The wizard uses the chosen pile class and the soil type of the selected layer if already input, otherwise it needs to be input.

As applicable, additional information necessary for determining $q_{sl}$ is detailed.

The value of $k_{pmax}$ is then calculated. Clicking the Send button sends this value to the layers definition table, for the selected soil layer.

Click the Close button and repeat the operation for each soil layer.

Automatic wizard for $q_{sl}$ and $k_{pmax}$

Clicking the Auto button automatically calculates the values of $q_{sl}$ and $k_{pmax}$ for all the soil layers.

A summary screen shows information concerning the various automatic calculations:

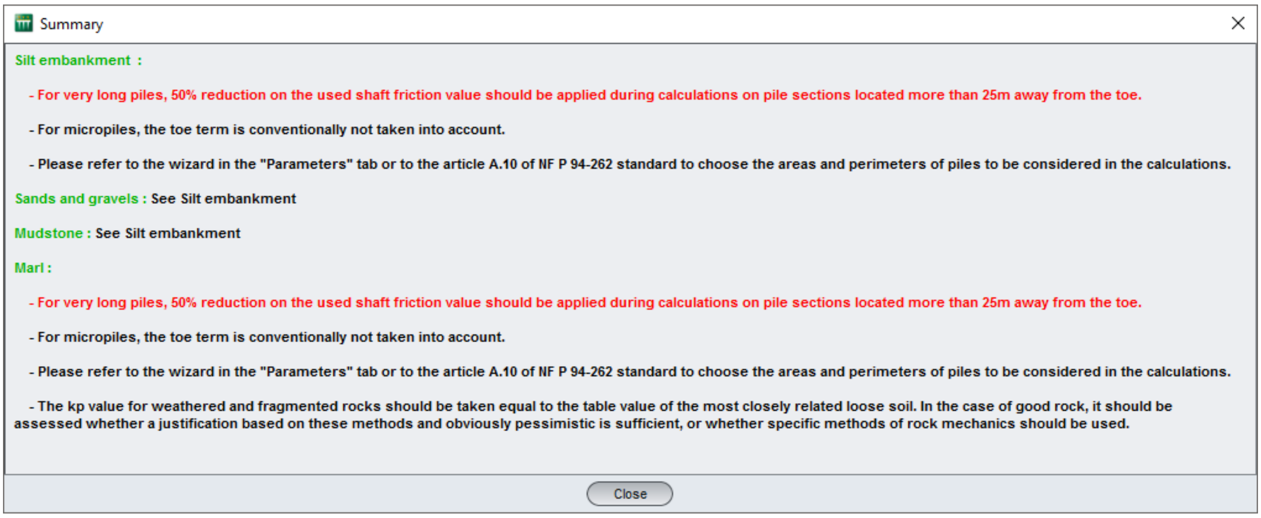



*Figure K.17 : Automatic wizard $q_{sl}$ and $k_{pmax}$ – EC7 – From pressuremeter results*

**From penetrometer results:**

The values of $q_{sl}$, $k_{cmin}$ and $k_{cmax}$ can be input manually or determined form the corresponding wizards, accessible at the bottom of the "soil layers definition" frame.

Limit unit shaft friction $q_{sl}$:

Select the soil layer concerned then click the button to open the wizard.

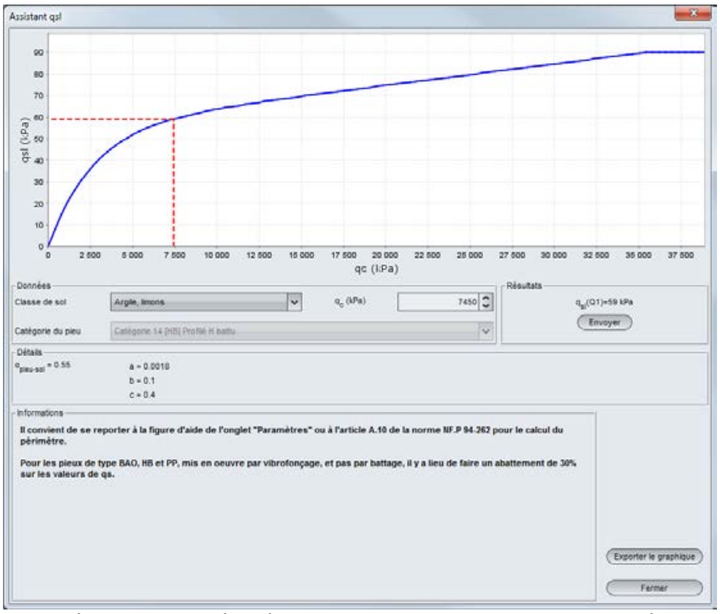



*Figure K.18 : Wizard $q_{sl}$ – EC7 – Form penetrometer results*

This wizard works exactly as that described above and, based on pressuremeter results.

Bearing capacity coefficients $k_{cmin}$ and $k_{cmax}$

Select a soil layer then click the button to open the wizard.

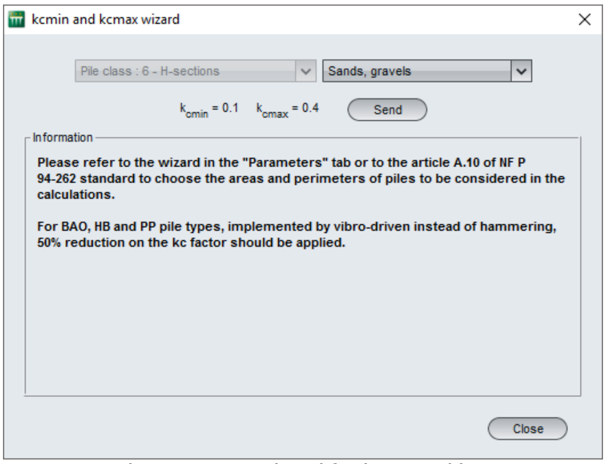



*Figure K.19 : Wizard for $k_{cmin}$ and $k_{cmax}$*

This wizard works exactly as that described above for determining $k_{pmax}$ in the case of a design based on pressuremeter results, except that this time, the wizard proposes 2 values: $k_{cmin}$ and $k_{cmax}$.

<u>Automatic wizard for $q_s$, $k_{cmin}$ and $k_{cmax}$</u>:

Similarly to design based on pressuremeter results, clicking the Auto button allows automatic calculation of the values of $q_{sl}$, $k_{cmin}$ and $k_{cmax}$ for all the soil layers.

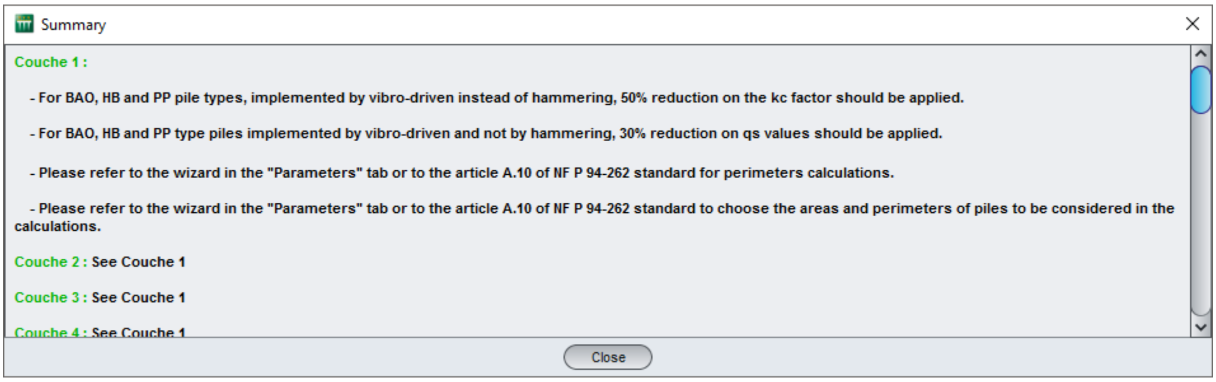



*Figure K.20 : Automatic wizard for $q_s$, $k_{cmin}$ and $k_{cmax}$ – EC7 – Based on penetrometer results*

#### K.3.3.2.2. Wizards for "Fascicle 62" projects, from pressuremeter results

The values of $q_s$ and $k_p$ can be input manually or determined from corresponding wizards, accessible at the bottom of the "soil layers definition" frame.

<u>Limit unit shaft friction $q_s$</u>:

Select the soil layer concerned then click the button to open the wizard.

- "Data" frame

  The wizard uses the value of $p_l$* previously input for the selected layer. The soil type and pile type should then be specified in the wizard.

- "Information" frame

  As applicable, additional information necessary for determining $q_s$ is detailed.

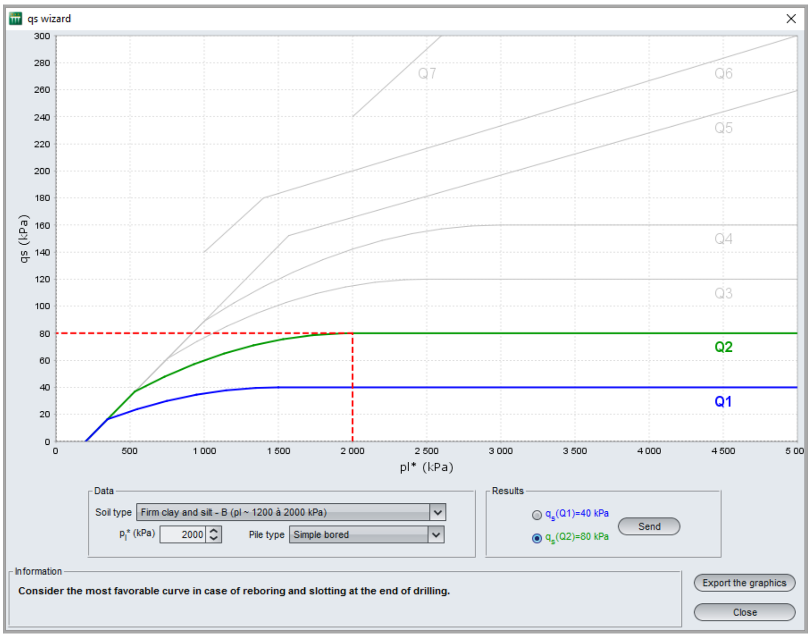



*Figure K.21 : Wizard $q_s$ (Fascicle 62) for a "Firm clay and silt" soil*

- Graph

  The graph presents the $q_s$ versus $p_l$* curve(s). The red line makes it possible to read the value of $q_s$ obtained for the input value of $p_l$*.

- "Results" frame

  Select the appropriate value when several curves are available. When the parameters proposed are acceptable, clicking the Send button enables the value of $q_s$ to be sent to the layers definition table for the soil layer selected.

Click the Close button and repeat the operation for each soil layer.

<u>Bearing factor $k_p$</u>:

Select a soil layer then click the button to open the wizard.

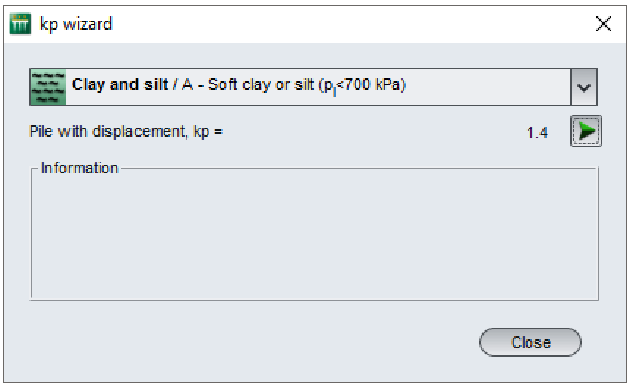



*Figure K.22 : Wizard $k_p$ (Fascicle 62) for a "soft clay or silt" type soil*

Here, one must select the soil class to which the soil layer concerned belongs, using the drop-down list.

The wizard automatically uses the implemented mode defined in the "Parameters" tab.

In the case of soils of class 'Rocks /A – Weathered ($p_l$ not defined)' and only in this case, the wizard can be used to modify the value of $k_p$.

Additional information is displayed according to the soil class selected in the "Information" frame.

Click the button to send the value to the selected line.

Click the Close button and repeat the operation for each soil layer.

### K.3.3.2.3. Help diagrams in the Fascicle 62 regulatory framework

The following help diagrams are accessible for projects for which the calculation context is covered by the regulatory framework of **Fascicle 62**.

<u>Conventional classification of soils</u>:

This help diagram is accessible whatever the design method chosen (from pressuremeter results or from penetrometer results).

Soil classification

**Conventional soil classification**

| Soil class | | Pressuremeter $p_l$ (MPa) | Penetrometer $q_c$ (MPa) |
|---|---|---|---|
| Clays , silts | A – Loose clays and silts | < 0,7 | < 3,0 |
| | B – Firm clays and silts | 1,2 à 2,0 | 3,0 à 6,0 |
| | C – Very firm to stiff clays | > 2,5 | > 6,0 |
| Sands, gravels | A – Loose | < 0,5 | < 5 |
| | B – Moderately compact | 1,0 à 2,0 | 8,0 à 15,0 |
| | C – Compact | > 2,5 | > 20,0 |
| Chalks | A – Loose | < 0,7 | < 5,0 |
| | B – Weathered | 1,0 à 2,5 | > 5,0 |
| | C – Compact | > 3,0 | |
| Marls, marly limestones | A – Soft | 1,5 à 4,0 | |
| | B – Compact | > 4,5 | |
| Rocks | A – Weathered | 2,5 à 4,0 | |
| | B – Fragmented | > 4,5 | |

*Figure K.23 : Help diagram: Conventional soil classification*

The following help diagrams are accessible for projects designed from pressuremeter results only.

<u>Bearing factor values $k_p$</u>:

Bearing factor kp

**« $k_p$ » bearing factor values**

| Soil class | | Implementation without displacement | Implementation with displacement |
|---|---|---|---|
| Clays , silts | A – Loose clays and silts | 1.1 | 1.4 |
| | B – Firm clays and silts | 1.2 | 1.5 |
| | C – Very firm to stiff clays | 1.3 | 1.6 |
| Sands, gravels | A – Loose | 1.0 | 4.2 |
| | B – Moderately compact | 1.1 | 3.7 |
| | C – Compacts | 1.2 | 3.2 |
| Chalks | A – Loose | 1.1 | 1.6 |
| | B – Weathered | 1.4 | 2.2 |
| | C – Compact | 1.8 | 2.6 |
| Marls, marly limestones | A – Soft<br>B – Compact | 1.8 | 2.6 |
| Rocks (1) | Weathered (1) | 1.1 à 1.8 | 1.8 à 3.2 |

(1) For these formations, $k_p$ value shall be chosen in the table for the most similar unconsolidated formation.

*Figure K.24 : Help diagram: Bearing factor values $k_p$*

<u>Friction $q_S$</u>:

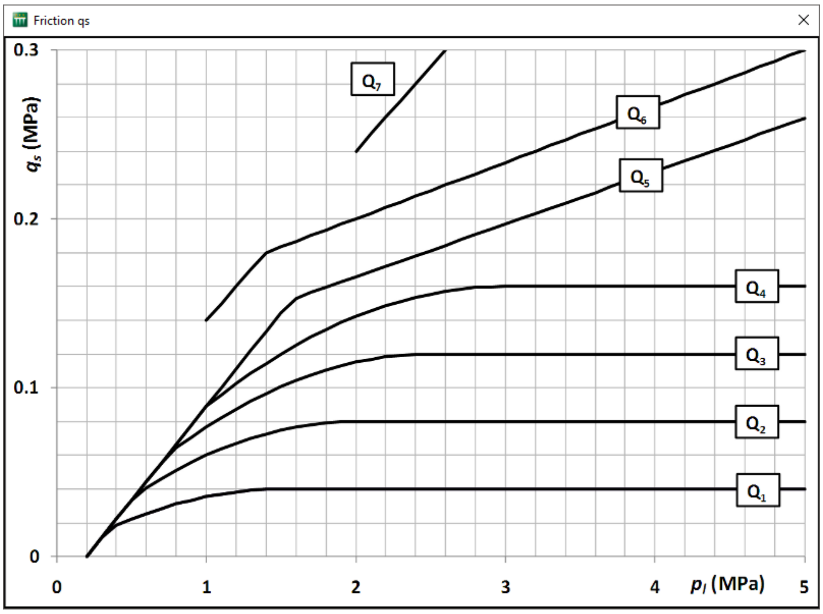



*Figure K.25 : Help diagram: Friction $q_S$*

<u>Help with classification of piles</u>:

The following table helps with the choice of curves for calculating the unit shaft friction $q_S$ (main types of piles used in engineering structures).

Pile classification

**Curve selection for unit friction $q_s$ (main pile types used in engineering structures)**

| Pile type | Clays, silts | | | Sands, gravels | | | Chalks | | | Marls | | Rocks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | A | B | C | A | B | C | A | B | |
| Simple bored | $Q_1$ | $Q_1$, $Q_2$(1) | $Q_2$, $Q_3$(1) | – | | | $Q_1$ | $Q_3$ | $Q_4$, $Q_5$(1) | $Q_3$ | $Q_4$, $Q_5$(1) | $Q_6$ |
| Sludge drilled | $Q_1$ | $Q_1$, $Q_2$(1) | | $Q_1$ | $Q_2$, $Q_1$(2) | $Q_3$, $Q_2$(2) | $Q_1$ | $Q_3$ | $Q_4$, $Q_5$(1) | $Q_3$ | $Q_4$, $Q_5$(1) | $Q_6$ |
| Drilled cased (reclaimed tube) | $Q_1$ | $Q_1$, $Q_2$(3) | | $Q_1$ | $Q_2$, $Q_1$(2) | $Q_3$, $Q_2$(2) | $Q_1$ | $Q_2$ | $Q_3$, $Q_4$(3) | $Q_3$ | $Q_4$ | – |
| Drilled cased (lost tube) | $Q_1$ | | | $Q_1$ | | $Q_2$ | (4) | | | $Q_2$ | $Q_3$ | – |
| Well (5) | $Q_1$ | $Q_2$ | $Q_3$ | – | | | $Q_1$ | $Q_2$ | $Q_3$ | $Q_4$ | $Q_5$ | $Q_6$ |
| Steel close-ended driven | $Q_1$ | $Q_2$ | | $Q_2$ | | $Q_3$ | (4) | | | $Q_3$ | $Q_4$ | $Q_4$ |
| Prefabricated concrete driven | $Q_1$ | $Q_2$ | | $Q_3$ | | | (4) | | | $Q_3$ | $Q_4$ | $Q_4$ |
| Driven Cast in situ | $Q_1$ | $Q_2$ | | $Q_2$ | | $Q_3$ | $Q_1$ | $Q_2$ | $Q_3$ | $Q_3$ | $Q_4$ | – |
| Coated driven | $Q_1$ | $Q_2$ | | $Q_3$ | | $Q_4$ | (4) | | | $Q_3$ | $Q_4$ | – |
| Low pressure injected | $Q_1$ | $Q_2$ | | $Q_3$ | | | $Q_2$ | $Q_3$ | $Q_4$ | $Q_5$ | | – |
| High pressure injected (6) | – | $Q_4$ | $Q_5$ | $Q_5$ | | $Q_6$ | | $Q_5$ | $Q_6$ | $Q_6$ | | $Q_7$(7) |

(1) Reboring and slotting at the end of drilling.
(2) Very long pile (longer than 30 m).
(3) Dry drilling, non-oscillated casing tube.
(4) If chalk: shaft friction can be very weak for some pile types. A specific study shall be carried out for each case.
(5) Neither cased nor hammered with lost ferrule (sometimes rough).
(6) Selective and repetitive injection at low flow.
(7) Selective and repetitive injection at low flow and preliminary treatment of fractured or cracked mediums and cavity filling.

*Figure K.26 : Help diagram: Pile classification*

Finally, the following help diagram is accessible for projects designed from penetrometer results only.

Bearing factor $k_c$:

Bearing factor kc

« $k_c$ » bearing factor values

| Soil class | | Implementation without displacement | Implementation with displacement |
|---|---|---|---|
| Clays , silts | A – Loose clays and silts<br>B – Firm clays and silts<br>C – Very firm to stiff clays | 0.40 | 0.55 |
| Sands, gravels | A – Loose<br>B – Moderately compact<br>C – Compact | 0.15 | 0.50 |
| Chalks | A – Loose | 0.20 | 0.30 |
| | B – Weathered | 0.30 | 0.45 |

*Figure K.27 : Help diagram: Bearing factor values $k_c$*

### K.3.3.3. Data import

The Fondprof module can be used to import soil layer data from the Windows® clipboard (also see example 2 in chapter K.4.2).

#### K.3.3.3.1. Data import procedure

These soil "layer" data are imported in the following way:

- prepare/recover an Excel® spreadsheet comprising the data to be imported;
- open this spreadsheet and copy the data into the Windows® clipboard
- open the "Table Modification" wizard " and click the Import... button;

  Tip: If you are working in the EC7 regulatory framework – Standard NF.P94-262: before clicking the Import... button, create the first soil layer 'Layer 1' by clicking the button, then select the required soil class. This soil class will then be automatically input into the imported lines;
- in this wizard, specify the lines interval to be imported. If the first line on the spreadsheet comprises column headers, it should be ignored (and import should therefore begin on line 2).

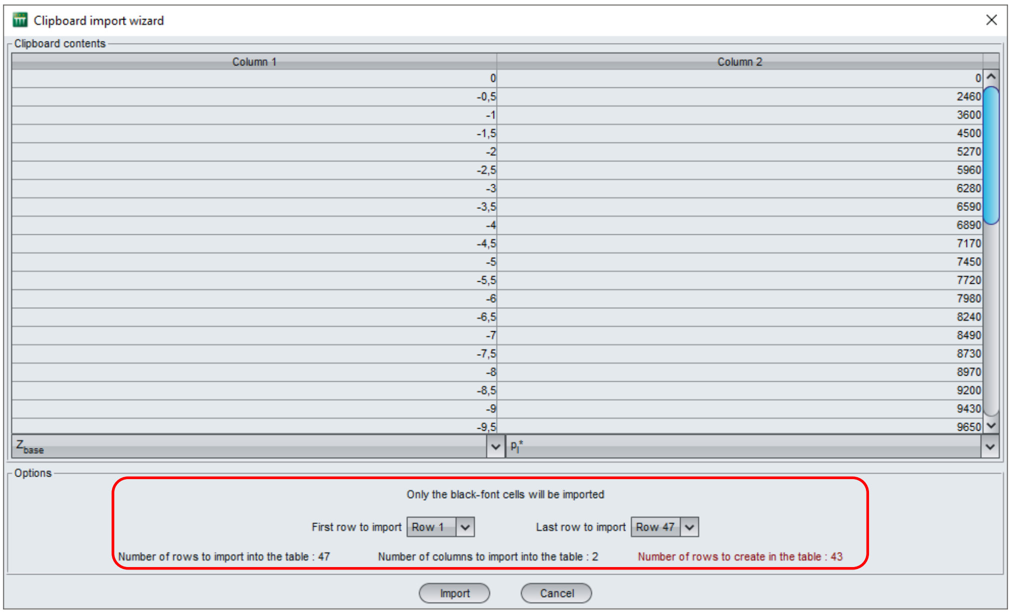



*Figure K.28 : Data import wizard*

- click the Import... button;
  - the table modification wizard then displays the imported data. Click the Close button: the imported soil layers were created with a default name, the soil class (copied from the first line if EC7 regulatory framework) and the values of the parameters as filled out in the spreadsheet.

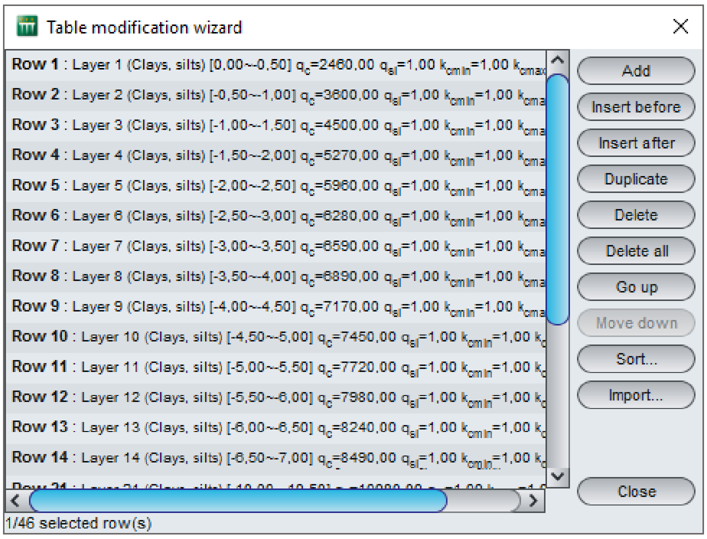



*Figure K.29 : Table modification wizard*

#### K.3.3.3.2. Format of spreadsheets to be imported

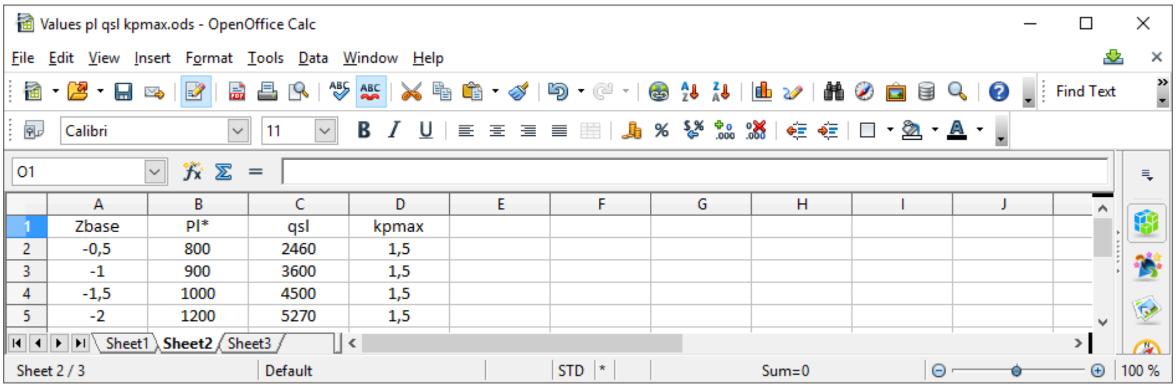
Below are examples of spreadsheet formats to be used.

For each of the cases mentioned below, the screenshot illustrates the data specific to Fondprof according to the regulatory framework and the design method, in accordance with the order shown in the application's Layers tab.

Note: Not all the data columns have to be filled out (but the $Z_{base}$ data however is mandatory).

<u>EC7 regulatory framework – Pressuremeter design method:</u>

Imported data: $Z_{base}$, $p_{l^*}$, $q_{sl}$ and $k_{pmax}$.

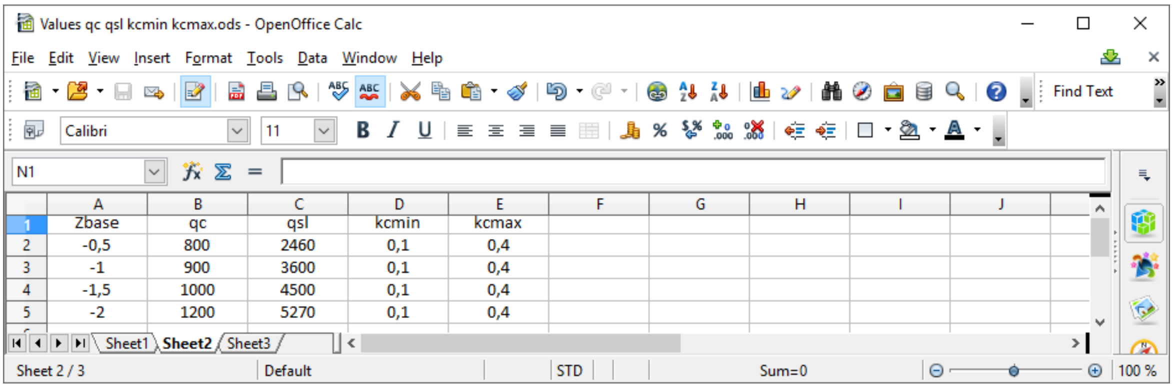



| | A | B | C | D |
|---|---|---|---|---|
| 1 | Zbase | Pl* | qsl | kpmax |
| 2 | -0,5 | 800 | 2460 | 1,5 |
| 3 | -1 | 900 | 3600 | 1,5 |
| 4 | -1,5 | 1000 | 4500 | 1,5 |
| 5 | -2 | 1200 | 5270 | 1,5 |

*Figure K.30 : Format of spreadsheet to be imported (EC7 regulatory framework – pressuremeter design)*

<u>EC7 regulatory framework – Penetrometer design method:</u>

Imported data: $Z_{base}$, $q_c$, $q_{sl}$, $k_{cmin}$ and $k_{cmax}$.

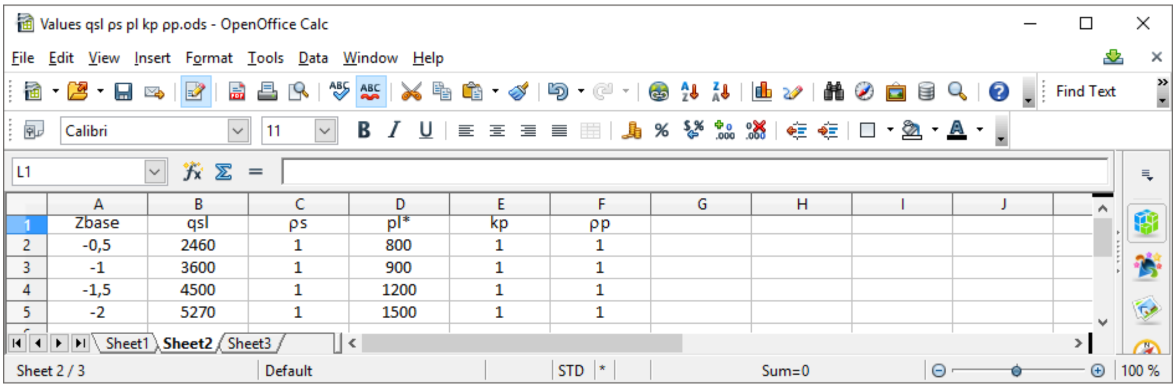



| | A | B | C | D | E |
|---|---|---|---|---|---|
| 1 | Zbase | qc | qsl | kcmin | kcmax |
| 2 | -0,5 | 800 | 2460 | 0,1 | 0,4 |
| 3 | -1 | 900 | 3600 | 0,1 | 0,4 |
| 4 | -1,5 | 1000 | 4500 | 0,1 | 0,4 |
| 5 | -2 | 1200 | 5270 | 0,1 | 0,4 |

*Figure K.31 : Format of spreadsheet to be imported (regulatory framework EC7 – penetrometer design)*

<u>Other regulatory frameworks – Pressuremeter design method:</u>

Imported data: $Z_{base}$, $q_{sl}$, $\rho_s$, $p_{l^*}$, $k_p$ and $\rho_p$.




| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| 1 | Zbase | qsl | ρs | pl* | kp | ρp |
| 2 | -0,5 | 2460 | 1 | 800 | 1 | 1 |
| 3 | -1 | 3600 | 1 | 900 | 1 | 1 |
| 4 | -1,5 | 4500 | 1 | 1200 | 1 | 1 |
| 5 | -2 | 5270 | 1 | 1500 | 1 | 1 |

*Figure K.32 : Format of spreadsheet to be imported (other regulatory frameworks – pressuremeter design)*

<u>Other regulatory frameworks – Penetrometer design method:</u>

Imported data: Zbase, qsl, ρs, qc, kc and ρp.

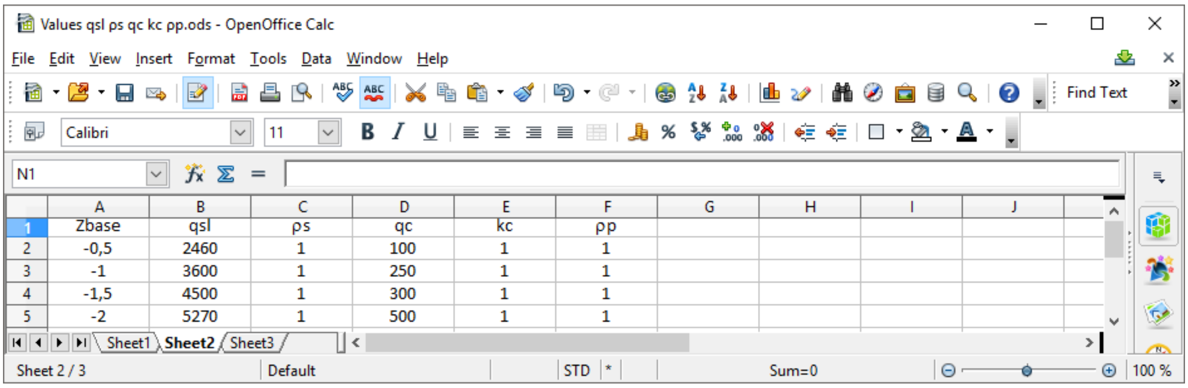



*Figure K.33 : Format of spreadsheet to be imported*
*(other regulatory frameworks – penetrometer design)*

The data checks are the same as those mentioned in Table K.12.

In some cases, if the imported values are outside the acceptable range, Fondprof automatically corrects the values: for example, if values higher than 1 are input in the spreadsheet for the $\rho_p$ and $\rho_s$ coefficients, Fondprof reduces these values to 1.0 after import.

### K.3.4. "Calculation" tab

This last tab is used to select a stop criterion for the calculation.

One of the three calculation modes should be chosen.

- Imposed load at pile head (default choice proposed):


*Figure K.34 : Calculation criterion: Imposed load at pile head*

- Imposed stress at pile head:


*Figure K.35 : Calculation criterion: Imposed stress at pile head*

➢ Imposed length:


*Figure K.36 : Calculation criterion: Imposed length*

The following table describes the data concerning the various calculation criteria:

| **Name** | **Unit** | **Default value** | **Display condition** | **Mandatory value** | **Local checks** |
|---|---|---|---|---|---|
| Load at pile head | kN | 0.00 | If "Imposed load at pile head" criterion | Yes | ≠ 0 |
| Stress at pile head | kPa | 0.00 | If "Imposed stress at pile head" criterion | Yes | ≠ 0 |
| Criterion applied to the combination | - | First combination of the list associated with the regulatory framework | If "Imposed load at pile head" or "imposed stress at pile head" criterion | Yes | - |
| Pile length | m | 0.00 | If "Imposed length" criterion | Yes | > 0 |

*Table K.14 : Calculation criteria*

## K.3.5. Calculation and results

### K.3.5.1. Calculation

The calculation can be started from any tab provided that the tabs are correctly filled out, in other words when they are all marked with a green tick (for example: Layers).

They are marked with a red cross (example: Layers) until they are correctly filled out (data missing or not conforming to the required values).

To start the calculation, click the Start calculation button.

To display the calculation results, click the See results button.

### K.3.5.2. Results

The following window is used to choose the type of results to be displayed. Different types of results are available in the case of the Fondprof module:

- numerical results: formatted results and results tables;
- graphical results: superposed bearing capacity curves.

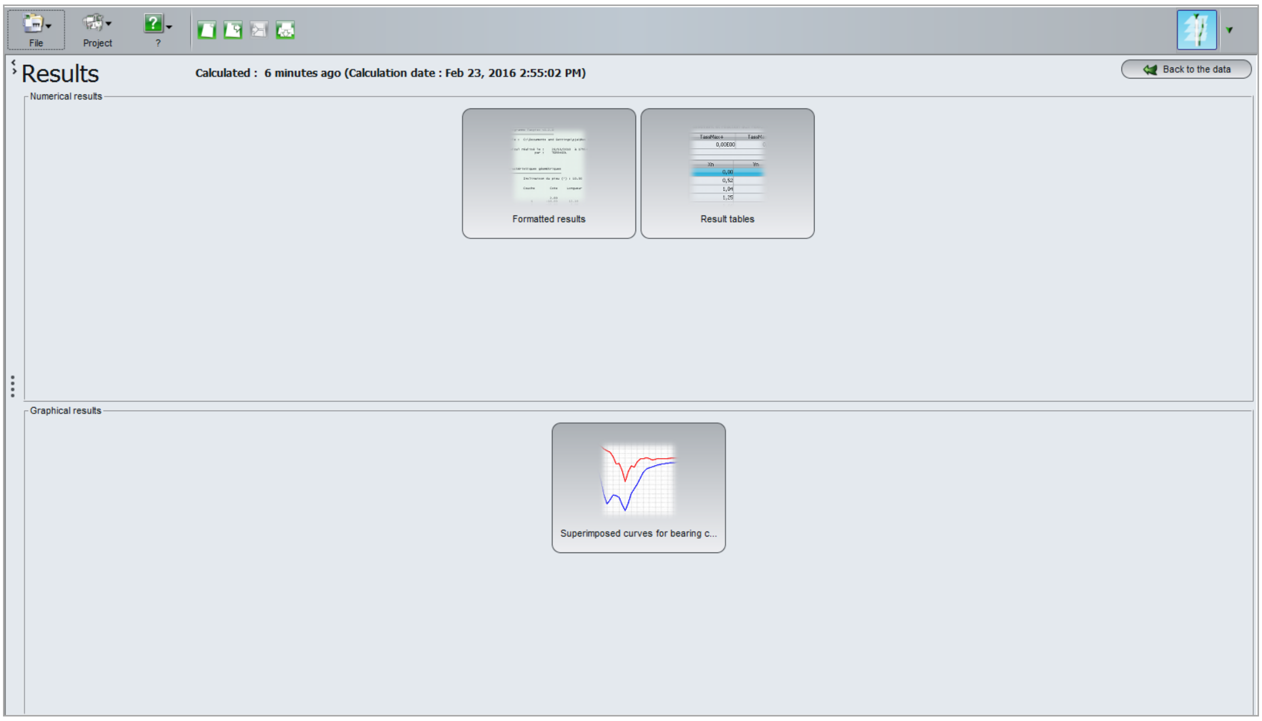



*Figure K.37 : Results window*

### K.3.5.2.1. Formatted numerical results

The formatted numerical results contain:

- a reminder of the data: the calculation options, the general parameters and the characteristics of the layers;
- a reminder of the calculation criterion;
- a table giving the following for each calculation step (until the stop criterion is reached):
  - ➢ the layer present at every design level;
  - ➢ the design level (m);
  - ➢ the limit unit shaft friction value $q_{sl}$ (kPa) at this elevation;
  - ➢ the equivalent limit pressure $pl_e$ (kPa) and pressuremeter bearing factor $k_p$ values calculated at this elevation in the case of a pressuremeter calculation;
  - ➢ the equivalent base resistance $q_{ce}$ (kPa) and penetrometer bearing capacity factor $k_c$ values calculated at this elevation in the case of a penetrometer calculation;
  - ➢ the value of the total shaft friction limit load $Q_s$ (kN) for a pile ended to this elevation;
  - ➢ the value of the limit base load $Q_p$ (kN) for a pile ended to this elevation;
  - ➢ the bearing capacities (kN) for the various load combinations:
    - o EC7 case: quasi-permanent SLS, characteristic SLS, permanent and transient ULS (fundamental) and accidental ULS;
    - o Fascicle 62 case: Creep, quasi-permanent SLS, rare SLS, permanent and transient ULS (fundamental) and accidental ULS;
    - o DTU 13.2 case: SLS and ULS;
    - o case of a free calculation: Coeff i (one column per combination).

```
File :  E:\Users\mto\Documents\Foxtav3\fondprof\CAPACITE PROTANTE PIEU ISOLÉ\capacite protante pieu isolé[FP].resu

Calcul réalisé le :    02/09/2013  à 18h19
              par :    Terrasol

Options du calcul :
    - calcul basé sur des paramètres issus du pressiomètre de Ménard
    - calcul selon les règles de la norme NF P 94 262
    - profil de pression limite pl* défini par points de mesure
    - pour pieu de catégorie :  6
    - pour pieu travaillant en compression

Combinaisons      ELS-QP     ELS-CARA    ELU-FOND    ELU-ACC

Frottement        0.503       0.615       0.719      0.791
Pointe            0.359       0.439       0.719      0.791

Cote de référence :     2.000

Section du pieu :       0.300
Périmètre :             0.300

Caractéristiques des couches (données utilisateur)

couche    base       pl*       qsl      kpmin      kpmax

  01      -7.00     800.0     75.53      1.00       1.65
  02     -12.00    2000.0    130.94      1.00       1.65
  03     -20.00     900.0     61.31      1.00       1.30
  04     -25.00    2200.0    155.95      1.00       1.60

Pas du calcul :       0.40

==========================================================================

                    **************
                    ***SOLUTION***
                    **************

   Calcul à longueur imposée : L =   25.00
```

| couche | cote | qsl | ple | kp | Qs | Qp |
|---|---|---|---|---|---|---|
| 01 | 2.00 | 75.53 | 800.0 | 1.000 | 0.0 | 240.0 |
| 01 | 1.60 | 75.53 | 800.0 | 1.084 | 9.1 | 260.2 |
| 01 | 1.20 | 75.53 | 800.0 | 1.168 | 18.1 | 280.4 |
| 01 | 0.80 | 75.53 | 800.0 | 1.252 | 27.2 | 300.6 |
| 01 | 0.40 | 75.53 | 800.0 | 1.337 | 36.3 | 320.8 |
| 01 | 0.00 | 75.53 | 800.0 | 1.421 | 45.3 | 341.0 |
| 01 | -0.40 | 75.53 | 800.0 | 1.505 | 54.4 | 361.2 |
| 01 | -0.80 | 75.53 | 800.0 | 1.589 | 63.4 | 381.4 |
| 01 | -1.20 | 75.53 | 800.0 | 1.650 | 72.5 | 396.0 |

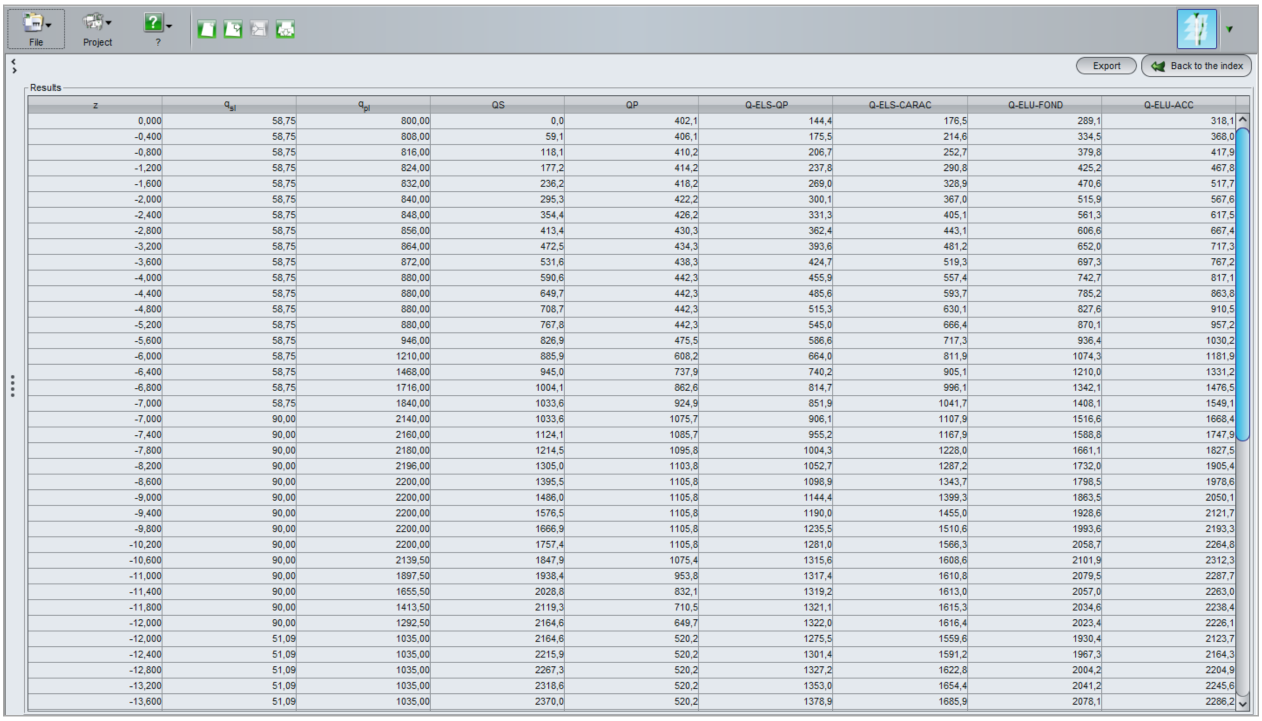
| couche | cote | qsl | ple | kp | Qs | Qp | ELS-QP | ELS-CARA | ELU-FOND | ELU-ACC |
|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 2.00 | 75.53 | 800.0 | 1.000 | 0.0 | 240.0 | 86.2 | 105.4 | 172.6 | 189.8 |
| 01 | 1.60 | 75.53 | 800.0 | 1.084 | 9.1 | 260.2 | 98.0 | 119.8 | 193.6 | 213.0 |
| 01 | 1.20 | 75.53 | 800.0 | 1.168 | 18.1 | 280.4 | 109.8 | 134.2 | 214.6 | 236.1 |
| 01 | 0.80 | 75.53 | 800.0 | 1.252 | 27.2 | 300.6 | 121.6 | 148.7 | 235.7 | 259.3 |
| 01 | 0.40 | 75.53 | 800.0 | 1.337 | 36.3 | 320.8 | 133.4 | 163.1 | 256.7 | 282.4 |
| 01 | 0.00 | 75.53 | 800.0 | 1.421 | 45.3 | 341.0 | 145.2 | 177.6 | 277.7 | 305.5 |
| 01 | -0.40 | 75.53 | 800.0 | 1.505 | 54.4 | 361.2 | 157.0 | 192.0 | 298.8 | 328.7 |
| 01 | -0.80 | 75.53 | 800.0 | 1.589 | 63.4 | 381.4 | 168.8 | 206.4 | 319.8 | 351.8 |
| 01 | -1.20 | 75.53 | 800.0 | 1.650 | 72.5 | 396.0 | 178.6 | 218.4 | 336.9 | 370.6 |
| 01 | -1.60 | 75.53 | 800.0 | 1.650 | 81.6 | 396.0 | 183.2 | 224.0 | 343.4 | 377.8 |
| 01 | -2.00 | 75.53 | 800.0 | 1.650 | 90.6 | 396.0 | 187.8 | 229.6 | 349.9 | 384.9 |
| 01 | -2.40 | 75.53 | 800.0 | 1.650 | 99.7 | 396.0 | 192.3 | 235.2 | 356.4 | 392.1 |
| 01 | -2.80 | 75.53 | 800.0 | 1.650 | 108.8 | 396.0 | 196.9 | 240.7 | 362.9 | 399.3 |
| 01 | -3.20 | 75.53 | 800.0 | 1.650 | 117.8 | 396.0 | 201.4 | 246.3 | 369.4 | 406.4 |
| 01 | -3.60 | 75.53 | 800.0 | 1.650 | 126.9 | 396.0 | 206.0 | 251.9 | 376.0 | 413.6 |
| 01 | -4.00 | 75.53 | 800.0 | 1.650 | 136.0 | 396.0 | 210.5 | 257.5 | 382.5 | 420.8 |
| 01 | -4.40 | 75.53 | 800.0 | 1.650 | 145.0 | 396.0 | 215.1 | 263.0 | 389.0 | 427.9 |
| 01 | -4.80 | 75.53 | 800.0 | 1.650 | 154.1 | 396.0 | 219.7 | 268.6 | 395.5 | 435.1 |
| 01 | -5.20 | 75.53 | 800.0 | 1.650 | 163.1 | 396.0 | 224.2 | 274.2 | 402.0 | 442.3 |
| 01 | -5.60 | 75.53 | 800.6 | 1.650 | 172.2 | 396.3 | 228.9 | 279.9 | 408.8 | 449.7 |
| 01 | -6.00 | 75.53 | 815.0 | 1.650 | 181.3 | 403.4 | 236.0 | 288.6 | 420.4 | 462.5 |
| 01 | -6.40 | 75.53 | 848.6 | 1.650 | 190.3 | 420.1 | 246.5 | 301.5 | 438.9 | 482.8 |
| 01 | -6.80 | 75.53 | 901.4 | 1.650 | 199.4 | 446.2 | 260.5 | 318.5 | 464.2 | 510.7 |
| 01 | -7.00 | 75.53 | 935.0 | 1.650 | 203.9 | 462.8 | 268.7 | 328.6 | 479.4 | 527.4 |
| 02 | -7.00 | 130.94 | 980.0 | 1.650 | 203.9 | 485.1 | 276.7 | 338.4 | 495.4 | 545.0 |
| 02 | -7.40 | 130.94 | 1028.0 | 1.650 | 219.6 | 508.9 | 293.2 | 358.5 | 523.8 | 576.2 |
| 02 | -7.80 | 130.94 | 1112.0 | 1.650 | 235.4 | 550.4 | 316.0 | 386.4 | 565.0 | 621.6 |
| 02 | -8.20 | 130.94 | 1208.0 | 1.650 | 251.1 | 598.0 | 341.0 | 416.9 | 610.5 | 671.6 |
| 02 | -8.60 | 130.94 | 1304.0 | 1.650 | 266.8 | 645.5 | 365.9 | 447.4 | 655.9 | 721.6 |
| 02 | -9.00 | 130.94 | 1400.0 | 1.650 | 282.5 | 693.0 | 390.9 | 478.0 | 701.4 | 771.6 |
| 02 | -9.40 | 130.94 | 1496.0 | 1.650 | 298.2 | 740.5 | 415.8 | 508.5 | 746.8 | 821.6 |
| 02 | -9.80 | 130.94 | 1592.0 | 1.650 | 313.9 | 788.0 | 440.8 | 539.0 | 792.3 | 871.7 |
| 02 | -10.20 | 130.94 | 1688.0 | 1.650 | 329.6 | 835.6 | 465.8 | 569.5 | 837.8 | 921.7 |
| 02 | -10.60 | 130.94 | 1783.1 | 1.650 | 345.3 | 882.6 | 490.6 | 599.9 | 882.9 | 971.3 |
| 02 | -11.00 | 130.94 | 1856.4 | 1.650 | 361.1 | 918.9 | 511.5 | 625.5 | 920.3 | 1012.5 |
| 02 | -11.40 | 130.94 | 1899.6 | 1.650 | 376.8 | 940.3 | 527.1 | 644.5 | 947.0 | 1041.8 |
| 02 | -11.80 | 130.94 | 1912.5 | 1.650 | 392.5 | 946.7 | 537.3 | 657.0 | 962.9 | 1059.3 |
| 02 | -12.00 | 130.94 | 1907.7 | 1.650 | 400.3 | 944.3 | 540.4 | 660.8 | 966.8 | 1063.6 |
| 03 | -12.00 | 61.31 | 1896.9 | 1.300 | 400.3 | 739.8 | 467.0 | 571.0 | 819.7 | 901.8 |
| 03 | -12.40 | 61.31 | 1869.4 | 1.300 | 407.7 | 729.1 | 466.8 | 570.8 | 817.3 | 899.2 |
| 03 | -12.80 | 61.31 | 1821.2 | 1.300 | 415.1 | 710.3 | 463.8 | 567.1 | 809.1 | 890.1 |
| 03 | -13.20 | 61.31 | 1766.2 | 1.300 | 422.4 | 688.8 | 459.8 | 562.2 | 799.0 | 879.0 |
| 03 | -13.60 | 61.31 | 1711.2 | 1.300 | 429.8 | 667.4 | 455.8 | 557.3 | 788.9 | 867.9 |
| 03 | -14.00 | 61.31 | 1656.2 | 1.300 | 437.1 | 645.9 | 451.8 | 552.4 | 778.7 | 856.7 |
| 03 | -14.40 | 61.31 | 1601.2 | 1.300 | 444.5 | 624.5 | 447.8 | 547.5 | 768.6 | 845.6 |
| 03 | -14.80 | 61.31 | 1546.2 | 1.300 | 451.8 | 603.0 | 443.8 | 542.6 | 758.5 | 834.4 |
| 03 | -15.20 | 61.31 | 1491.2 | 1.300 | 459.2 | 581.6 | 439.8 | 537.7 | 748.3 | 823.3 |
| 03 | -15.60 | 61.31 | 1436.2 | 1.300 | 466.6 | 560.1 | 435.8 | 532.8 | 738.2 | 812.1 |
| 03 | -16.00 | 61.31 | 1381.2 | 1.300 | 473.9 | 538.7 | 431.8 | 527.9 | 728.1 | 801.0 |
| 03 | -16.40 | 61.31 | 1326.2 | 1.300 | 481.3 | 517.2 | 427.8 | 523.0 | 717.9 | 789.8 |
| 03 | -16.80 | 61.31 | 1271.2 | 1.300 | 488.6 | 495.8 | 423.8 | 518.2 | 707.8 | 778.7 |
| 03 | -17.20 | 61.31 | 1216.2 | 1.300 | 496.0 | 474.3 | 419.8 | 513.3 | 697.7 | 767.5 |
| 03 | -17.60 | 61.31 | 1161.3 | 1.300 | 503.3 | 452.9 | 415.8 | 508.4 | 687.5 | 756.4 |
| 03 | -18.00 | 61.31 | 1106.3 | 1.300 | 510.7 | 431.4 | 411.8 | 503.5 | 677.4 | 745.2 |
| 03 | -18.40 | 61.31 | 1051.3 | 1.300 | 518.1 | 410.0 | 407.8 | 498.6 | 667.3 | 734.1 |
| 03 | -18.80 | 61.31 | 1005.2 | 1.300 | 525.4 | 392.0 | 405.0 | 495.2 | 659.6 | 725.7 |
| 03 | -19.20 | 61.31 | 989.9 | 1.300 | 532.8 | 386.1 | 406.6 | 497.1 | 660.7 | 726.8 |
| 03 | -19.60 | 61.31 | 1006.5 | 1.300 | 540.1 | 392.5 | 412.6 | 504.5 | 670.6 | 737.7 |
| 03 | -20.00 | 61.31 | 1054.8 | 1.300 | 547.5 | 411.4 | 423.1 | 517.3 | 689.4 | 758.5 |
| 03 | -20.00 | 61.31 | 1054.8 | 1.300 | 547.5 | 411.4 | 423.1 | 517.3 | 689.4 | 758.5 |
| 04 | -20.00 | 155.95 | 1095.0 | 1.600 | 547.5 | 525.6 | 464.1 | 567.4 | 771.5 | 848.8 |
| 04 | -20.40 | 155.95 | 1147.0 | 1.600 | 566.2 | 550.6 | 482.4 | 589.9 | 802.9 | 883.4 |
| 04 | -20.80 | 155.95 | 1238.0 | 1.600 | 584.9 | 594.2 | 507.5 | 620.6 | 847.8 | 932.7 |
| 04 | -21.20 | 155.95 | 1342.0 | 1.600 | 603.6 | 644.2 | 534.9 | 654.0 | 897.2 | 987.0 |
| 04 | -21.60 | 155.95 | 1446.0 | 1.600 | 622.3 | 694.1 | 562.2 | 687.4 | 946.5 | 1041.3 |
| 04 | -22.00 | 155.95 | 1550.0 | 1.600 | 641.1 | 744.0 | 589.5 | 720.9 | 995.9 | 1095.6 |
| 04 | -22.40 | 155.95 | 1654.0 | 1.600 | 659.8 | 793.9 | 616.9 | 754.3 | 1045.2 | 1149.9 |
| 04 | -22.80 | 155.95 | 1758.0 | 1.600 | 678.5 | 843.8 | 644.2 | 787.7 | 1094.6 | 1204.2 |
| 04 | -23.00 | 155.95 | 1810.0 | 1.600 | 687.8 | 868.8 | 657.9 | 804.4 | 1119.2 | 1231.3 |

*Figure K.38 : Formatted numerical results (case of EC7 regulatory framework)*

### K.3.5.2.2. Results table

On the whole, this concerns the same results as those detailed for the formatted results in the previous chapter, but this time presented in the form of a table, and without the data summary part.

The values of $pl_e/k_p$ or $q_{ce}/k_c$ are however replaced in the table by the display of the $q_{pl}$ column (base resistance pressure, in kPa).




| z | $q_{sl}$ | $q_{pl}$ | QS | QP | Q-ELS-QP | Q-ELS-CARAC | Q-ELU-FOND | Q-ELU-ACC |
|---|---|---|---|---|---|---|---|---|
| 0,000 | 58,75 | 800,00 | 0,0 | 402,1 | 144,4 | 176,5 | 289,1 | 318,1 |
| -0,400 | 58,75 | 808,00 | 59,1 | 406,1 | 175,5 | 214,6 | 334,5 | 368,0 |
| -0,800 | 58,75 | 816,00 | 118,1 | 410,2 | 206,7 | 252,7 | 379,8 | 417,9 |
| -1,200 | 58,75 | 824,00 | 177,2 | 414,2 | 237,8 | 290,8 | 425,2 | 467,8 |
| -1,600 | 58,75 | 832,00 | 236,2 | 418,2 | 269,0 | 328,9 | 470,6 | 517,7 |
| -2,000 | 58,75 | 840,00 | 295,3 | 422,2 | 300,1 | 367,0 | 515,9 | 567,6 |
| -2,400 | 58,75 | 848,00 | 354,4 | 426,2 | 331,3 | 405,1 | 561,3 | 617,5 |
| -2,800 | 58,75 | 856,00 | 413,4 | 430,3 | 362,4 | 443,1 | 606,6 | 667,4 |
| -3,200 | 58,75 | 864,00 | 472,5 | 434,3 | 393,6 | 481,2 | 652,0 | 717,3 |
| -3,600 | 58,75 | 872,00 | 531,6 | 438,3 | 424,7 | 519,3 | 697,3 | 767,2 |
| -4,000 | 58,75 | 880,00 | 590,6 | 442,3 | 455,9 | 557,4 | 742,7 | 817,1 |
| -4,400 | 58,75 | 880,00 | 649,7 | 442,3 | 485,6 | 593,7 | 785,2 | 863,8 |
| -4,800 | 58,75 | 880,00 | 708,7 | 442,3 | 515,3 | 630,1 | 827,6 | 910,5 |
| -5,200 | 58,75 | 880,00 | 767,8 | 442,3 | 545,0 | 666,4 | 870,1 | 957,2 |
| -5,600 | 58,75 | 946,00 | 826,9 | 475,5 | 586,6 | 717,3 | 936,4 | 1030,2 |
| -6,000 | 58,75 | 1210,00 | 885,9 | 608,2 | 664,0 | 811,9 | 1074,3 | 1181,9 |
| -6,400 | 58,75 | 1468,00 | 945,0 | 737,9 | 740,2 | 905,1 | 1210,0 | 1331,2 |
| -6,800 | 58,75 | 1716,00 | 1004,1 | 862,6 | 814,7 | 996,1 | 1342,1 | 1476,5 |
| -7,000 | 58,75 | 1840,00 | 1033,6 | 924,9 | 851,9 | 1041,7 | 1408,1 | 1549,1 |
| -7,000 | 90,00 | 2140,00 | 1033,6 | 1075,7 | 906,1 | 1107,9 | 1516,6 | 1668,4 |
| -7,400 | 90,00 | 2160,00 | 1124,1 | 1085,7 | 955,2 | 1167,9 | 1588,8 | 1747,9 |
| -7,800 | 90,00 | 2180,00 | 1214,5 | 1095,8 | 1004,3 | 1228,0 | 1661,1 | 1827,5 |
| -8,200 | 90,00 | 2196,00 | 1305,0 | 1103,8 | 1052,7 | 1287,2 | 1732,0 | 1905,4 |
| -8,600 | 90,00 | 2200,00 | 1395,5 | 1105,8 | 1098,9 | 1343,7 | 1798,5 | 1978,6 |
| -9,000 | 90,00 | 2200,00 | 1486,0 | 1105,8 | 1144,4 | 1399,3 | 1863,5 | 2050,1 |
| -9,400 | 90,00 | 2200,00 | 1576,5 | 1105,8 | 1190,0 | 1455,0 | 1928,6 | 2121,7 |
| -9,800 | 90,00 | 2200,00 | 1666,9 | 1105,8 | 1235,5 | 1510,6 | 1993,6 | 2193,3 |
| -10,200 | 90,00 | 2200,00 | 1757,4 | 1105,8 | 1281,0 | 1566,3 | 2058,7 | 2264,8 |
| -10,600 | 90,00 | 2139,50 | 1847,9 | 1075,4 | 1315,6 | 1608,6 | 2101,9 | 2312,3 |
| -11,000 | 90,00 | 1897,50 | 1938,4 | 953,8 | 1317,4 | 1610,8 | 2079,5 | 2287,7 |
| -11,400 | 90,00 | 1655,50 | 2028,8 | 832,1 | 1319,2 | 1613,0 | 2057,0 | 2263,0 |
| -11,800 | 90,00 | 1413,50 | 2119,3 | 710,5 | 1321,1 | 1615,3 | 2034,6 | 2238,4 |
| -12,000 | 90,00 | 1292,50 | 2164,6 | 649,7 | 1322,0 | 1616,4 | 2023,4 | 2226,1 |
| -12,000 | 51,09 | 1035,00 | 2164,6 | 520,2 | 1275,5 | 1559,6 | 1930,4 | 2123,7 |
| -12,400 | 51,09 | 1035,00 | 2215,9 | 520,2 | 1301,4 | 1591,2 | 1967,3 | 2164,3 |
| -12,800 | 51,09 | 1035,00 | 2267,3 | 520,2 | 1327,2 | 1622,8 | 2004,2 | 2204,9 |
| -13,200 | 51,09 | 1035,00 | 2318,6 | 520,2 | 1353,0 | 1654,4 | 2041,2 | 2245,6 |
| -13,600 | 51,09 | 1035,00 | 2370,0 | 520,2 | 1378,9 | 1685,9 | 2078,1 | 2286,2 |

*Figure K.39 : Results table (case of EC7 regulatory framework)*

### K.3.5.2.3. Graphical results: superposed bearing capacity curves

This graphic displays the bearing capacity of the pile for each combination versus the depth. As for the formatted results, the combinations displayed depend on the regulatory framework chosen:

- EC7 case: quasi-permanent SLS, characteristic SLS, permanent and transient ULS (fundamental) and accidental ULS;
- Fascicle 62 case: Creep, quasi-permanent SLS, rare SLS, permanent and transient ULS (fundamental) and accidental ULS;
- DTU 13.2 case: SLS and ULS;
- case of a free calculation: Coeff i (one column per combination created in the "Parameters" tab).

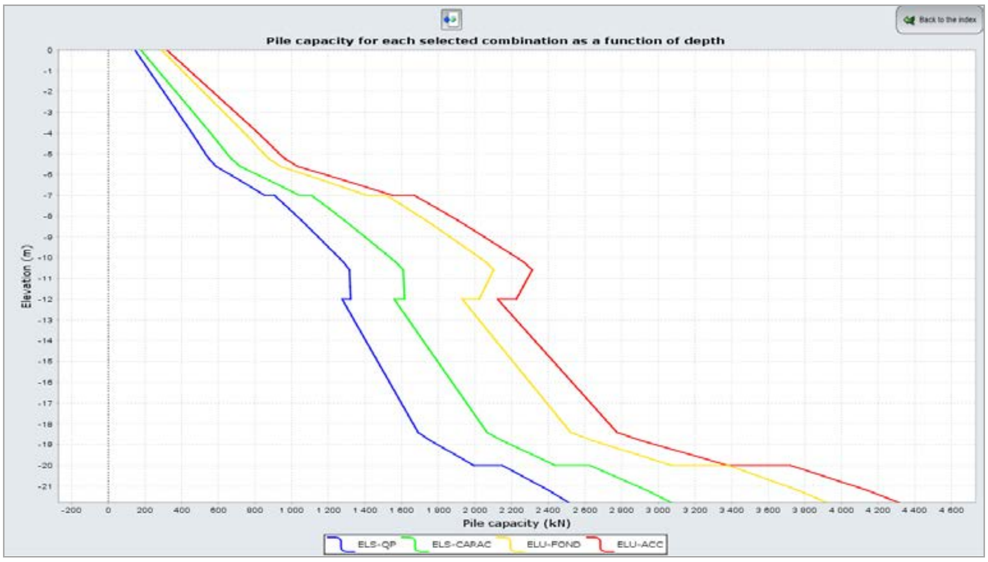
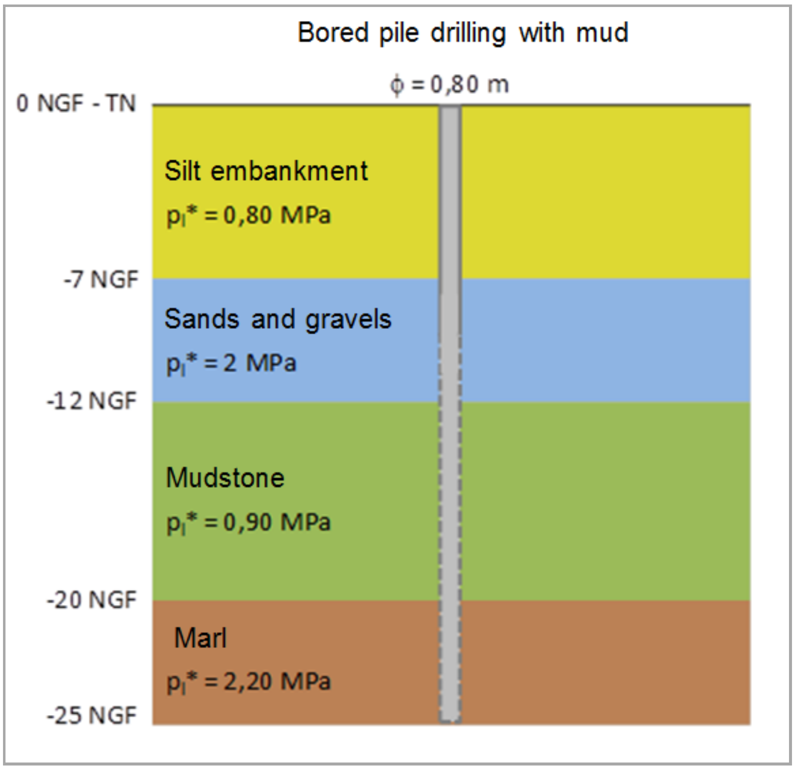



*Figure K.40 : Superposed bearing capacity curves (case of EC7 regulatory framework)*

# K.4. Calculation examples

## K.4.1. Example 1

This example deals with the case of a single deep foundation in a heterogeneous soil medium: the purpose of the exercise is to evaluate the vertical bearing capacity as defined in standard NF.P 94-262 applying Eurocode 7 for deep foundations.




For a circular concrete pile (ϕ800 mm) implemented by mud drilling, the aim is to determine the bearing capacity as a function of the embedment depth and to determine at what depth the maximum stress in the concrete is reached.

### K.4.1.1. Calculation of bearing capacity for a given pile depth

Double-click the Foxta icon to start the programme, choose the type of login and the preferred language then click the OK button.

#### K.4.1.1.1. Data input

When the application opens, Foxta proposes:

- Creating a new project,
- Opening an existing project,
- Automatically opening the last project used.

In the case of this example:

- Choose to create a new project by selecting the New project .radio button.
- Click the OK button.

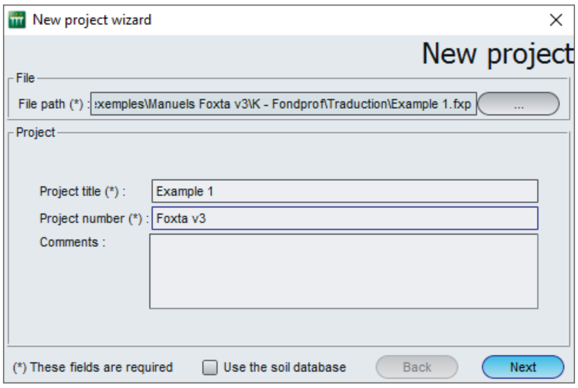
## New project wizard

"File" frame

- Fill out the project file path by clicking the [ ... ] button.
- Give the project a name and save it.

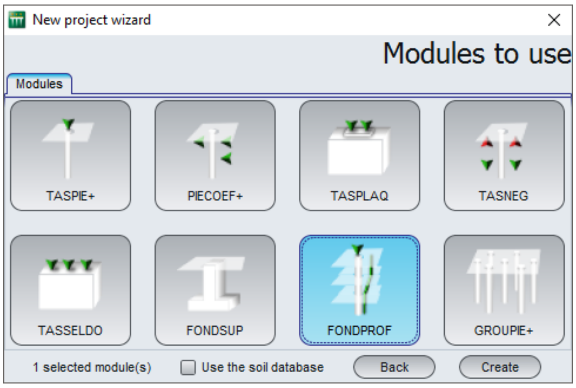
"Project" frame

- Give the project a title,
- Input a project number,
- Add comments if necessary,
- Leave the "Use the soil database" box unticked (we will not use the database for this example) and click the [ Next ] button.




## New project wizard: Choice of modules

Select the FONDPROF module, then click the [ Create ] button.




The FONDPROF data input window then appears. The various data tabs proposed must be filled out.

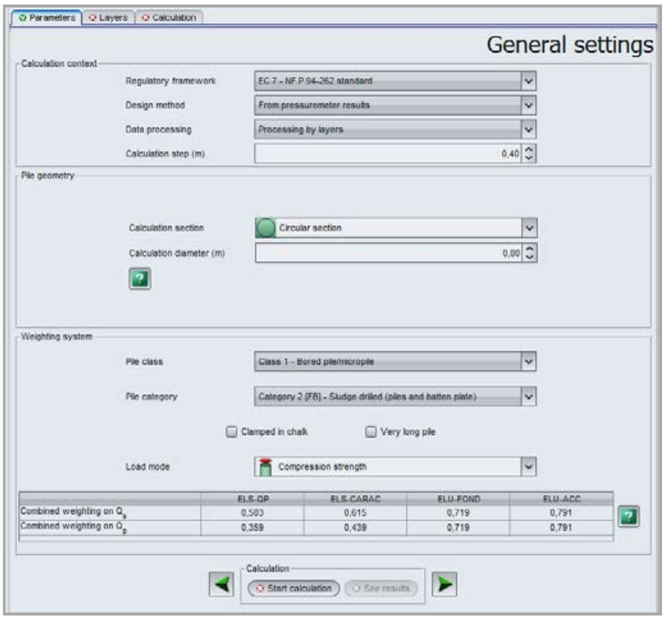
### K.4.1.1.2. "Parameters" tab

This tab concerns the general calculation parameters.

"Calculation context" frame

- Regulatory framework: EC 7 – Standard NF.P 94-262.
- Design method: From pressuremeter results.
- Data processing: Processing by layers.
- Calculation step (m): 0.40 m.

*Note:* Processing by layers means that a single average limit pressure value per layer should be entered. This processing is suited to the case of a geotechnical model pre-defined by the user. In this case, the limit pressure value is taken as being homogeneous over the height of the layer (see chapter K.3.2.1.2).




"Pile geometry" frame

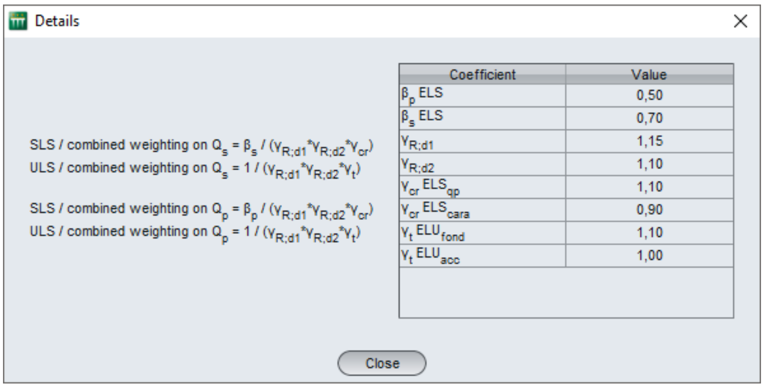
- Calculation section: Circular calculation section.
- Calculation diameter (m): 0.80 m.

"Weighting system" frame

- Pile class: Class 1 – Drilled pile/micro-pile.
- Pile category: Category 2 [FB] – Sludge drilled (piles and rectangular piles).
- Embedded in chalk: Unticked.
- Load mode: Compression strength.

*Note:* The weightings applied to $Q_s$ and $Q_p$ now also depend on the nature of the embedment layer (chalk or other).

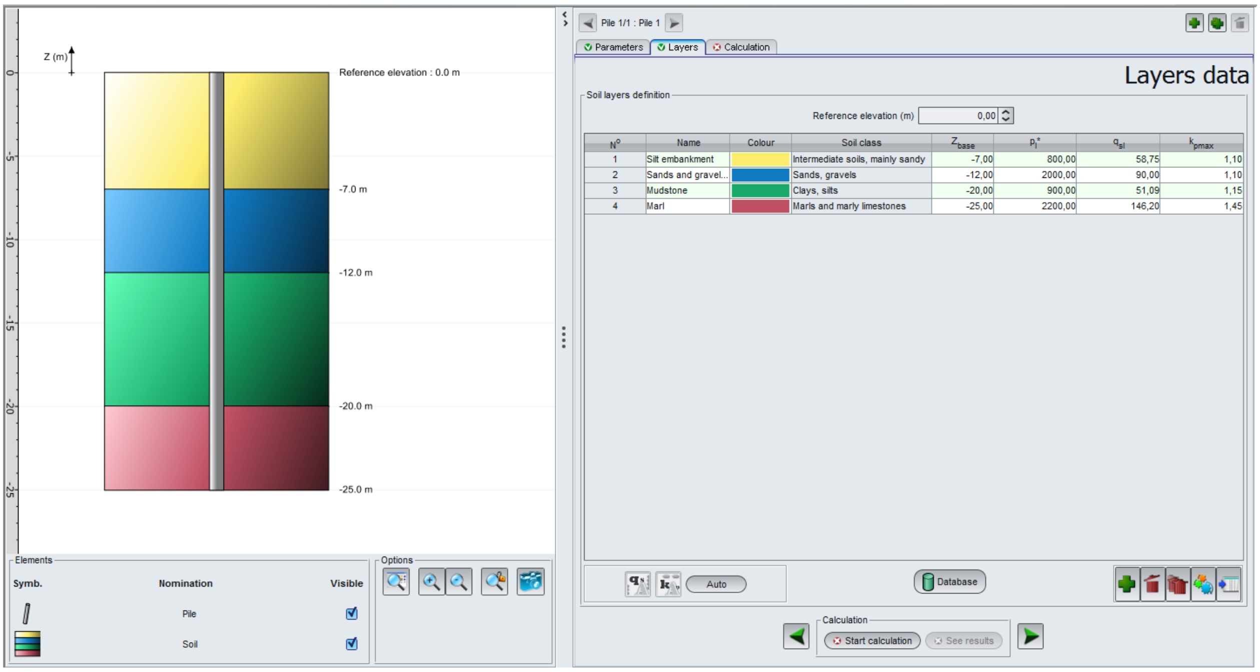
The project weighting details can be displayed by clicking the button.




To move onto the next tab, click either the name of the "Layers" tab, or the button.

### K.4.1.1.3. "Layers" tab

This tab is used to define the soil layers.




Reference elevation: 0.00 m.

Click the ![+] button to create each of the layers.

For the various soil layers, input:

- Soil class.
- Elevation of base of layer $Z_{base}$ (m).
  *Note:* The model must stop below the base of the foundations. In the event of any uncertainty regarding their length, make provision for a margin of several metres.
- Average limit pressure value $p_l^*$ (kPa).
- Limit unit friction value $q_{sl}$ (kPa).
- Value of maximum bearing factor $k_{pmax}$ (valid as of embedment equivalent to 5 diameters).

| Name | Soil class | $Z_{base}$ (m) | $p_l^*$ (kPa) | $q_{sl}$ (kPa) | $k_{pmax}$ (-) |
|---|---|---|---|---|---|
| Silty embankment | Intermediate soils, mainly sandy | -7 | 800 | 58.75 | 1.10 |
| Sand and gravel | Sand, gravel | -12 | 2000 | 90.00 | 1.10 |
| Clays | Clay, Silt | -20 | 900 | 51.09 | 1.15 |
| Marl | Marl and marly limestone | -25 | 2200 | 146.20 | 1.45 |

The values of $q_{sl}$ and $k_{pmax}$ can be input by hand or calculated with the corresponding wizards, available at the bottom of the "Soil layers definition" frame. In this present case, we can use the automatic wizard described below.

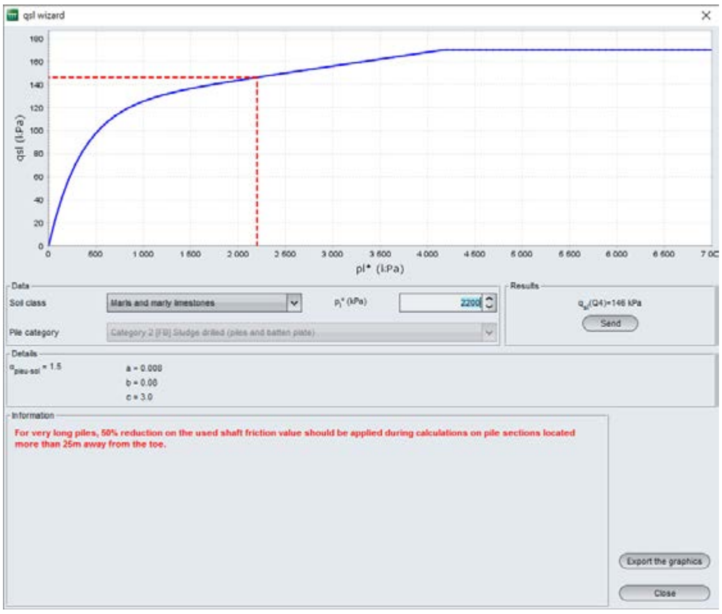
<u>Automatic wizard for $q_{sl}$ and $k_{pmax}$</u>

Clicking the Auto button automatically calculates the values of $q_{sl}$ and $k_{pmax}$ for all the soil layers.

However, in general, it is also possible to use the $q_{sl}$ and $k_{pmax}$ wizards individually for each layer:

<u>Wizard for $q_{sl}$</u>

Select the soil layer concerned then click the button to start the wizard.




- "Data" frame

  The wizard uses the data previously input for the selected layer (soil type, value of $p_l$*) as well as the chosen pile category. If the layer data have not yet been filled out, they can be input into the wizard.

- "Details" frame

  The $\alpha_{pile\text{-}soil}$ parameter and the values of a, b and c are automatically calculated as a function of the data input in the "Data" frame and are displayed here.

- "Information" frame

  Whenever necessary, additional information needed to determine $q_{sl}$ is detailed.

- Graph

  The graph displays the $q_{sl}$ versus $p_l$* curve in blue. The red line can be used to read the value of $q_{sl}$ obtained for the input value of $p_l$*.

- "Results" frame

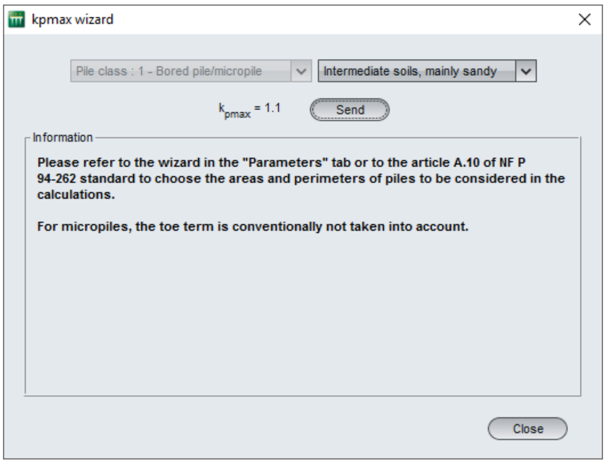
  When the proposed parameters are satisfactory, clicking the Send button enables the value of $q_{sl}$ to be sent to the layers definition table for the selected soil layer.

Click the Close button and repeat the operation for each of the soil layers.

Wizard for $k_{pmax}$

Select the soil layer concerned then click the button to start the wizard.




The wizard uses the pile class chosen and the type of soil selected if already input, otherwise it needs to be filled out.

When necessary, additional information needed to determine $q_{sl}$ is detailed.

The value of $k_{pmax}$ is then calculated. Clicking the Send button enables this value to be sent to the project for the selected soil layer.

Click the Close button and repeat the operation for each of the soil layers.

### K.4.1.1.4. "Calculation" tab

This tab concerns the criteria used to design the foundation.

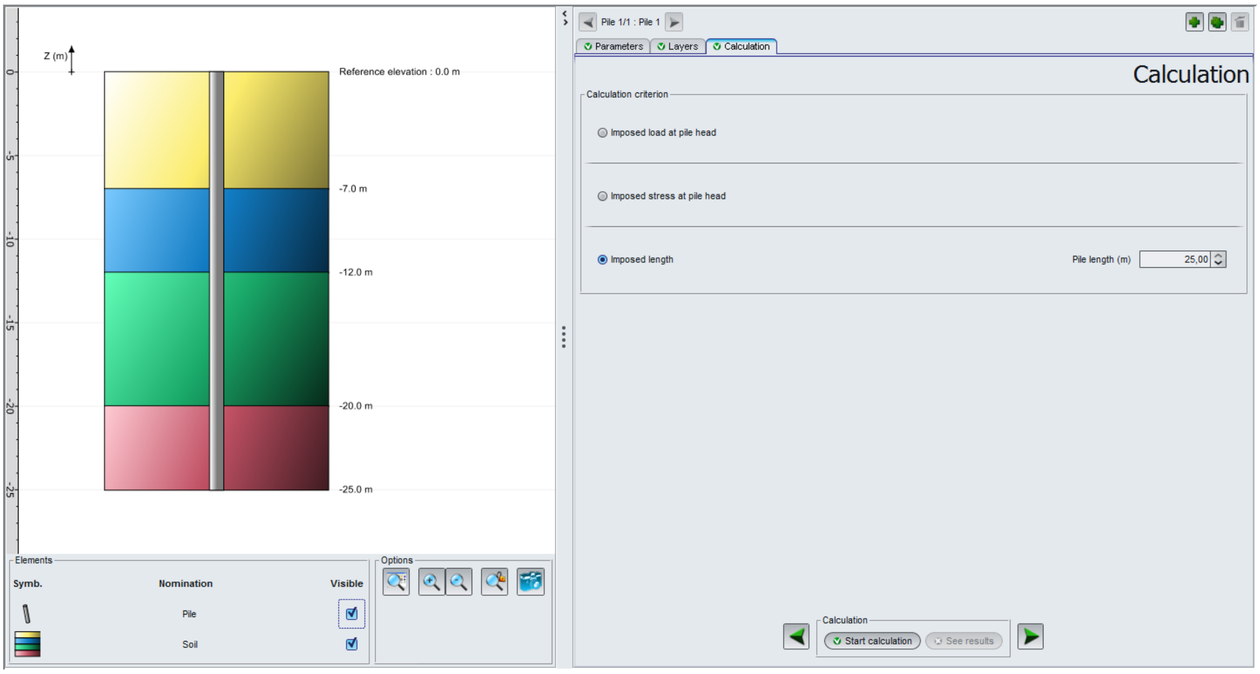
Three options are possible:

- "Imposed load at pile head": the software automatically checks for the foundation length able to take up the load applied at the pile head.
- "Imposed stress at pile head": the software automatically checks for the foundation length able to take up the stress applied at the pile head.
- "Imposed length": the software calculates the bearing capacity of the foundation for all calculation steps until the maximum length set by the user is reached.

Here we wish to analyse the variation in bearing capacity as a function of depth:

- Select "Imposed length": 25 m.

Save the project.




### K.4.1.1.5. Calculation and Results

**Calculation**

Until all the tabs have been correctly filled out, the button used to start calculation is displayed with a red cross: Start calculation.

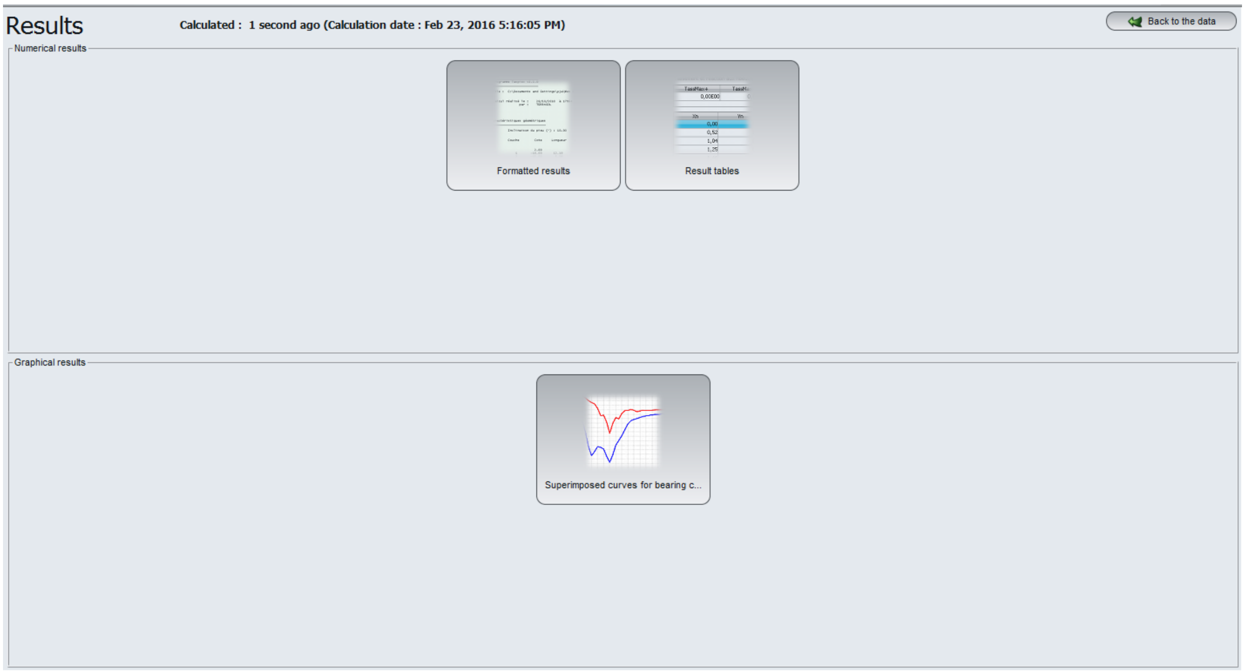
Once all the data have been correctly filled out, the Start calculation button becomes active and is accessible from all the tabs.

Clicking this button will start the calculation.

**Results**

To access the results in the form of tables and graphics, click the See results button.




<u>"Numerical results" frame</u>

The "Formatted results" and "Results tables" are accessible by clicking the corresponding button.

*Formatted results*

Copy all | Copy only the selection

Calcul à longueur imposée : L = 25.00

| couche | cote | qsl | ple | kp | Qs | Qp | ELS-QP | ELS-CARA | ELU-FOND | ELU-ACC |
|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 0.00 | 58.75 | 800.0 | 1.000 | 0.0 | 402.1 | 144.4 | 176.5 | 289.1 | 318.1 |
| 01 | -0.40 | 58.75 | 800.0 | 1.010 | 59.1 | 406.1 | 175.5 | 214.6 | 334.5 | 368.0 |
| 01 | -0.80 | 58.75 | 800.0 | 1.020 | 118.1 | 410.2 | 206.7 | 252.7 | 379.8 | 417.9 |
| 01 | -1.20 | 58.75 | 800.0 | 1.030 | 177.2 | 414.2 | 237.8 | 290.8 | 425.2 | 467.8 |
| 01 | -1.60 | 58.75 | 800.0 | 1.040 | 236.2 | 418.2 | 269.0 | 328.9 | 470.6 | 517.7 |
| 01 | -2.00 | 58.75 | 800.0 | 1.050 | 295.3 | 422.2 | 300.1 | 367.0 | 515.9 | 567.6 |
| 01 | -2.40 | 58.75 | 800.0 | 1.060 | 354.4 | 426.3 | 331.3 | 405.1 | 561.3 | 617.5 |
| 01 | -2.80 | 58.75 | 800.0 | 1.070 | 413.4 | 430.3 | 362.4 | 443.2 | 606.6 | 667.4 |
| 01 | -3.20 | 58.75 | 800.0 | 1.080 | 472.5 | 434.3 | 393.6 | 481.2 | 652.0 | 717.3 |
| 01 | -3.60 | 58.75 | 800.0 | 1.090 | 531.6 | 438.3 | 424.7 | 519.3 | 697.3 | 767.2 |
| 01 | -4.00 | 58.75 | 800.0 | 1.100 | 590.6 | 442.3 | 455.9 | 557.4 | 742.7 | 817.1 |
| 01 | -4.40 | 58.75 | 800.0 | 1.100 | 649.7 | 442.3 | 485.6 | 593.7 | 785.2 | 863.8 |
| 01 | -4.80 | 58.75 | 800.0 | 1.100 | 708.7 | 442.3 | 515.3 | 630.1 | 827.6 | 910.5 |
| 01 | -5.20 | 58.75 | 800.0 | 1.100 | 767.8 | 442.3 | 545.0 | 666.4 | 870.1 | 957.2 |
| 01 | -5.60 | 58.75 | 860.0 | 1.100 | 826.9 | 475.5 | 586.6 | 717.3 | 936.4 | 1030.2 |
| 01 | -6.00 | 58.75 | 1100.0 | 1.100 | 885.9 | 608.2 | 664.0 | 811.9 | 1074.3 | 1181.9 |
| 01 | -6.40 | 58.75 | 1340.0 | 1.096 | 945.0 | 737.9 | 740.2 | 905.1 | 1210.0 | 1331.2 |
| 01 | -6.80 | 58.75 | 1580.0 | 1.086 | 1004.1 | 862.6 | 814.7 | 996.2 | 1342.1 | 1476.5 |
| 01 | -7.00 | 58.75 | 1700.0 | 1.082 | 1033.6 | 924.9 | 851.9 | 1041.7 | 1408.1 | 1549.1 |
| 02 | -7.00 | 90.00 | 2000.0 | 1.070 | 1033.6 | 1075.7 | 906.1 | 1107.9 | 1516.6 | 1668.4 |
| 02 | -7.40 | 90.00 | 2000.0 | 1.080 | 1124.1 | 1085.7 | 955.2 | 1167.9 | 1588.8 | 1747.9 |
| 02 | -7.80 | 90.00 | 2000.0 | 1.090 | 1214.5 | 1095.8 | 1004.3 | 1228.0 | 1661.1 | 1827.5 |
| 02 | -8.20 | 90.00 | 2000.0 | 1.098 | 1305.0 | 1103.8 | 1052.7 | 1287.2 | 1732.0 | 1905.4 |
| 02 | -8.60 | 90.00 | 2000.0 | 1.100 | 1395.5 | 1105.8 | 1098.9 | 1343.7 | 1798.5 | 1978.6 |
| 02 | -9.00 | 90.00 | 2000.0 | 1.100 | 1486.0 | 1105.8 | 1144.4 | 1399.3 | 1863.5 | 2050.1 |
| 02 | -9.40 | 90.00 | 2000.0 | 1.100 | 1576.5 | 1105.8 | 1190.0 | 1455.0 | 1928.6 | 2121.7 |
| 02 | -9.80 | 90.00 | 2000.0 | 1.100 | [illegible] | 1105.8 | [illegible] | [illegible] | [illegible] | [illegible] |
| 02 | -10.20 | 90.00 | 2000.0 | 1.100 | 1757.4 | 1105.8 | 1281.0 | 1566.3 | 2058.7 | 2264.8 |
| 02 | -10.60 | 90.00 | 1945.0 | 1.100 | 1847.9 | 1075.4 | 1315.6 | 1608.6 | 2101.9 | 2312.3 |
| 02 | -11.00 | 90.00 | 1725.0 | 1.100 | 1938.4 | 953.8 | 1317.4 | 1610.8 | 2079.5 | 2287.7 |
| 02 | -11.40 | 90.00 | 1505.0 | 1.100 | 2028.8 | 832.1 | 1319.2 | 1613.0 | 2057.0 | 2263.0 |
| 02 | -11.80 | 90.00 | 1285.0 | 1.100 | 2119.3 | 710.5 | 1321.1 | 1615.3 | 2034.6 | 2238.4 |
| 02 | -12.00 | 90.00 | 1175.0 | 1.100 | 2164.6 | 649.7 | 1322.0 | 1616.4 | 2023.4 | 2226.1 |
| 03 | -12.00 | 51.09 | 900.0 | 1.150 | 2164.6 | 520.2 | 1275.5 | 1559.6 | 1930.4 | 2123.7 |
| 03 | -12.40 | 51.09 | 900.0 | 1.150 | 2215.9 | 520.2 | 1301.4 | 1591.2 | 1967.3 | 2164.3 |
| 03 | -12.80 | 51.09 | 900.0 | 1.150 | 2267.3 | 520.2 | 1327.2 | 1622.8 | 2004.2 | 2204.9 |
| 03 | -13.20 | 51.09 | 900.0 | 1.150 | 2318.6 | 520.2 | 1353.0 | 1654.4 | 2041.2 | 2245.6 |
| 03 | -13.60 | 51.09 | 900.0 | 1.150 | 2370.0 | 520.2 | 1378.9 | 1685.9 | 2078.1 | 2286.2 |
| 03 | -14.00 | 51.09 | 900.0 | 1.150 | 2421.4 | 520.2 | 1404.7 | 1717.5 | 2115.0 | 2326.8 |
| 03 | -14.40 | 51.09 | 900.0 | 1.150 | [illegible] | 520.2 | [illegible] | [illegible] | [illegible] | [illegible] |
| 03 | -14.80 | 51.09 | 900.0 | 1.150 | 2524.1 | 520.2 | 1456.4 | 1780.7 | 2188.9 | 2408.1 |
| 03 | -15.20 | 51.09 | 900.0 | 1.150 | 2575.4 | 520.2 | 1482.2 | 1812.3 | 2225.8 | 2448.7 |
| 03 | -15.60 | 51.09 | 900.0 | 1.150 | 2626.8 | 520.2 | 1508.1 | 1843.9 | 2262.7 | 2489.3 |
| 03 | -16.00 | 51.09 | 900.0 | 1.150 | 2678.2 | 520.2 | 1533.9 | 1875.5 | 2299.7 | 2529.9 |
| 03 | -16.40 | 51.09 | 900.0 | 1.150 | 2729.5 | 520.2 | 1559.7 | 1907.1 | 2336.6 | 2570.6 |
| 03 | -16.80 | 51.09 | 900.0 | 1.150 | 2780.9 | 520.2 | 1585.6 | 1938.6 | 2373.5 | 2611.2 |
| 03 | -17.20 | 51.09 | 900.0 | 1.150 | 2832.3 | 520.2 | 1611.4 | 1970.2 | 2410.4 | 2651.8 |
| 03 | -17.60 | 51.09 | 900.0 | 1.150 | 2883.6 | 520.2 | 1637.2 | 2001.8 | 2447.4 | 2692.5 |
| 03 | -18.00 | 51.09 | 900.0 | 1.150 | 2935.0 | 520.2 | 1663.1 | 2033.4 | 2484.3 | 2733.1 |
| 03 | -18.40 | 51.09 | 900.0 | 1.150 | 2986.3 | 520.2 | 1688.9 | 2065.0 | 2521.2 | 2773.7 |
| 03 | -18.80 | 51.09 | 1095.0 | 1.150 | 3037.7 | 633.0 | 1755.2 | 2146.1 | 2639.2 | 2903.5 |
| 03 | -19.20 | 51.09 | 1355.0 | 1.150 | 3089.1 | 783.3 | 1835.0 | 2243.6 | 2784.2 | 3063.0 |
| 03 | -19.60 | 51.09 | 1615.0 | 1.150 | 3140.4 | 933.6 | 1914.8 | 2341.2 | 2929.2 | 3222.5 |
| 03 | -20.00 | 51.09 | 1875.0 | 1.144 | 3191.8 | 1078.2 | 1992.5 | 2436.3 | 3070.1 | 3377.6 |

Reduction of $p_{le}$*

The formatted results give:

➢ A reminder of the calculation parameters.

➢ The results for the various calculation steps. The bearing capacities for the various load combinations are available: quasi-permanent SLS, characteristic SLS, permanent and transient ULS (fundamental) and accidental ULS.

*Results tables*

Export | Back to the index

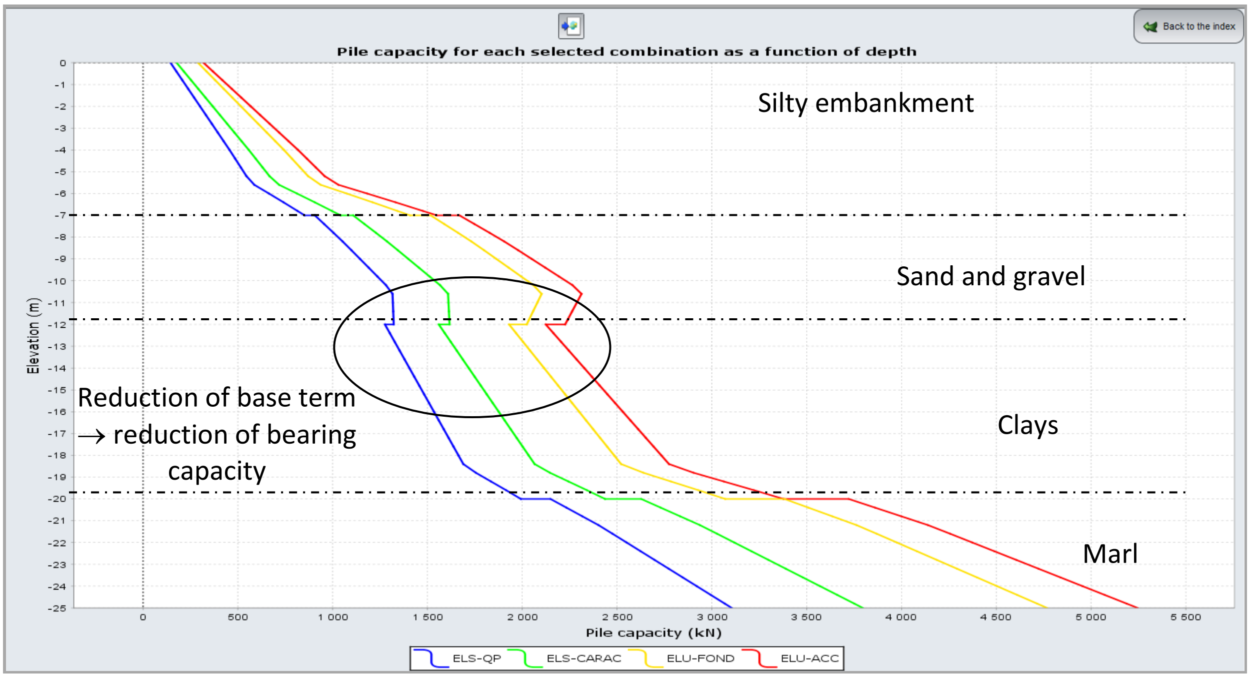
Results

| z | $q_{sl}$ | $q_{pl}$ | QS | QP | Q-ELS-QP | Q-ELS-CARAC | Q-ELU-FOND | Q-ELU-ACC |
|---|---|---|---|---|---|---|---|---|
| 0,000 | 58,75 | 800,00 | 0,0 | 402,1 | 144,4 | 176,5 | 289,1 | 318,1 |
| -0,400 | 58,75 | 808,00 | 59,1 | 406,1 | 175,5 | 214,6 | 334,5 | 368,0 |
| -0,800 | 58,75 | 816,00 | 118,1 | 410,2 | 206,7 | 252,7 | 379,8 | 417,9 |
| -1,200 | 58,75 | 824,00 | 177,2 | 414,2 | 237,8 | 290,8 | 425,2 | 467,8 |
| -1,600 | 58,75 | 832,00 | 236,2 | 418,2 | 269,0 | 328,9 | 470,6 | 517,7 |
| -2,000 | 58,75 | 840,00 | 295,3 | 422,2 | 300,1 | 367,0 | 515,9 | 567,6 |
| -2,400 | 58,75 | 848,00 | 354,4 | 426,2 | 331,3 | 405,1 | 561,3 | 617,5 |
| -2,800 | 58,75 | 856,00 | 413,4 | 430,3 | 362,4 | 443,1 | 606,6 | 667,4 |
| -3,200 | 58,75 | 864,00 | 472,5 | 434,3 | 393,6 | 481,2 | 652,0 | 717,3 |
| -3,600 | 58,75 | 872,00 | 531,6 | 438,3 | 424,7 | 519,3 | 697,3 | 767,2 |
| -4,000 | 58,75 | 880,00 | 590,6 | 442,3 | 455,9 | 557,4 | 742,7 | 817,1 |
| -4,400 | 58,75 | 880,00 | 649,7 | 442,3 | 485,6 | 593,7 | 785,2 | 863,8 |
| -4,800 | 58,75 | 880,00 | 708,7 | 442,3 | 515,3 | 630,1 | 827,6 | 910,5 |
| -5,200 | 58,75 | 880,00 | 767,8 | 442,3 | 545,0 | 666,4 | 870,1 | 957,2 |
| -5,600 | 58,75 | 946,00 | 826,9 | 475,5 | 586,6 | 717,3 | 936,4 | 1030,2 |
| -6,000 | 58,75 | 1210,00 | 885,9 | 608,2 | 664,0 | 811,9 | 1074,3 | 1181,9 |
| -6,400 | 58,75 | 1468,00 | 945,0 | 737,9 | 740,2 | 905,1 | 1210,0 | 1331,2 |
| -6,800 | 58,75 | 1716,00 | 1004,1 | 862,6 | 814,7 | 996,1 | 1342,1 | 1476,5 |
| -7,000 | 58,75 | 1840,00 | 1033,6 | 924,9 | 851,9 | 1041,7 | 1408,1 | 1549,1 |
| -7,000 | 90,00 | 2140,00 | 1033,6 | 1075,7 | 906,1 | 1107,9 | 1516,6 | 1668,4 |
| -7,400 | 90,00 | 2160,00 | 1124,1 | 1085,7 | 955,2 | 1167,9 | 1588,8 | 1747,9 |
| -7,800 | 90,00 | 2180,00 | 1214,5 | 1095,8 | 1004,3 | 1228,0 | 1661,1 | 1827,5 |
| -8,200 | 90,00 | 2196,00 | 1305,0 | 1103,8 | 1052,7 | 1287,2 | 1732,0 | 1905,4 |
| -8,600 | 90,00 | 2200,00 | 1395,5 | 1105,8 | 1098,9 | 1343,7 | 1798,5 | 1978,6 |
| -9,000 | 90,00 | 2200,00 | 1486,0 | 1105,8 | 1144,4 | 1399,3 | 1863,5 | 2050,1 |
| -9,400 | 90,00 | 2200,00 | 1576,5 | 1105,8 | 1190,0 | 1455,0 | 1928,6 | 2121,7 |
| -9,800 | 90,00 | 2200,00 | 1666,9 | 1105,8 | 1235,5 | 1510,6 | 1993,6 | 2193,3 |
| -10,200 | 90,00 | 2200,00 | 1757,4 | 1105,8 | 1281,0 | 1566,3 | 2058,7 | 2264,8 |
| -10,600 | 90,00 | 2139,50 | 1847,9 | 1075,4 | 1315,6 | 1608,6 | 2101,9 | 2312,3 |
| -11,000 | 90,00 | 1897,50 | 1938,4 | 953,8 | 1317,4 | 1610,8 | 2079,5 | 2287,7 |
| -11,400 | 90,00 | 1655,50 | 2028,8 | 832,1 | 1319,2 | 1613,0 | 2057,0 | 2263,0 |
| -11,800 | 90,00 | 1413,50 | 2119,3 | 710,5 | 1321,1 | 1615,3 | 2034,6 | 2238,4 |
| -12,000 | 90,00 | 1292,50 | 2164,6 | 649,7 | 1322,0 | 1616,4 | 2023,4 | 2226,1 |
| -12,000 | 51,09 | 1035,00 | 2164,6 | 520,2 | 1275,5 | 1559,6 | 1930,4 | 2123,7 |
| -12,400 | 51,09 | 1035,00 | 2215,9 | 520,2 | 1301,4 | 1591,2 | 1967,3 | 2164,3 |
| -12,800 | 51,09 | 1035,00 | 2267,3 | 520,2 | 1327,2 | 1622,8 | 2004,2 | 2204,9 |
| -13,200 | 51,09 | 1035,00 | 2318,6 | 520,2 | 1353,0 | 1654,4 | 2041,2 | 2245,6 |
| -13,600 | 51,09 | 1035,00 | 2370,0 | 520,2 | 1378,9 | 1685,9 | 2078,1 | 2286,2 |

For each calculation step, the results table gives the results previously presented: bearing capacities for quasi-permanent SLS, characteristic SLS, permanent and transient ULS (fundamental) and accidental ULS.

<u>"Graphical results" frame</u>

The "superposed bearing capacity" curves are available by clicking the corresponding button.




This graphic gives the various bearing capacities down to the required depth of 25 m.

### K.4.1.2. Calculation of bearing capacity for a given pile stress

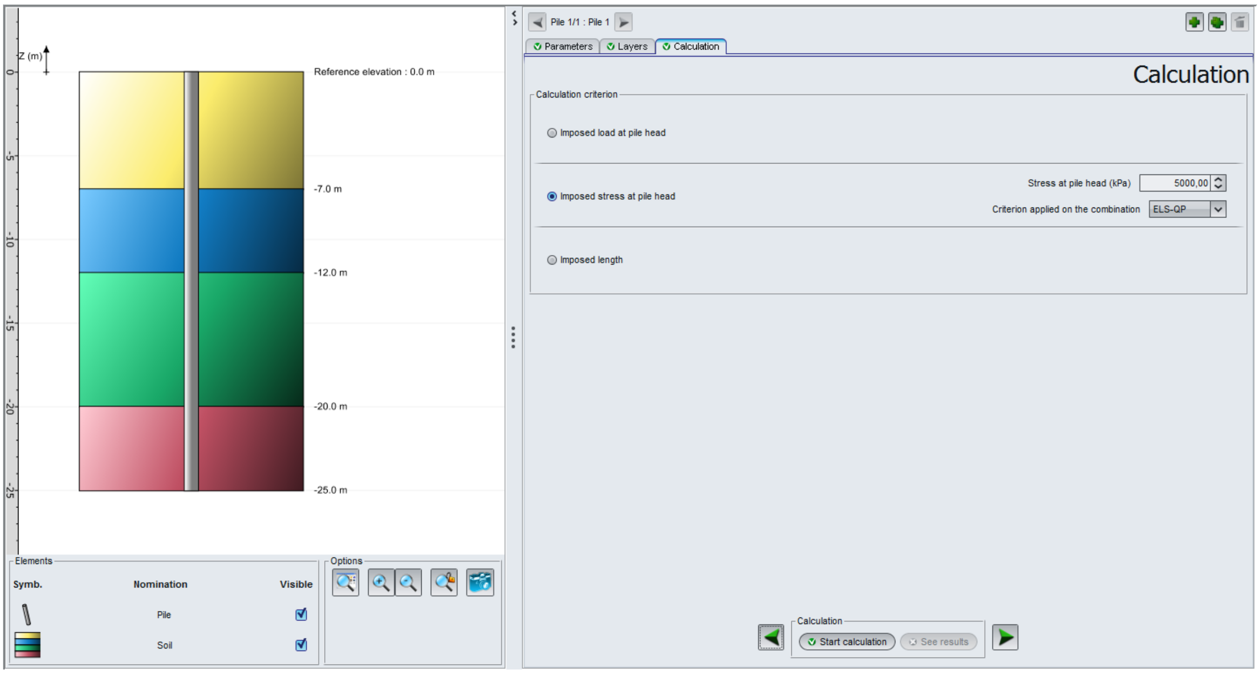
Here we aim to determine at what pile length a stress of 5 MPa is reached in the concrete.

Go back to the data by clicking the [Back to the data] button. Only the "Calculation" tab will be modified.

#### K.4.1.2.1. "Calculation" tab

This time please input:

- Imposed stress at pile head: 5000 kPa.
- Criterion applied to the combination: SLS-QP.




Now restart the calculation by clicking the [Start calculation] button then click the [See results] button.

### K.4.1.2.2. Calculation and Results

<u>"Numerical Results" frame</u>

*Formatted Results*

Calcul à charge imposée : Q = 2513.3 vis à vis de la combinaison : ELS-QP

| couche | cote | qsl | ple | kp | Qs | Qp | ELS-QP | ELS-CARA | ELU-FOND | ELU-ACC |
|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 0.00 | 58.75 | 800.0 | 1.000 | 0.0 | 402.1 | 144.4 | 176.5 | 289.1 | 318.1 |
| 01 | -0.40 | 58.75 | 800.0 | 1.010 | 59.1 | 406.1 | 175.5 | 214.6 | 334.5 | 368.0 |
| 01 | -0.80 | 58.75 | 800.0 | 1.020 | 118.1 | 410.2 | 206.7 | 252.7 | 379.8 | 417.9 |
| 01 | -1.20 | 58.75 | 800.0 | 1.030 | 177.2 | 414.2 | 237.8 | 290.8 | 425.2 | 467.8 |
| 01 | -1.60 | 58.75 | 800.0 | 1.040 | 236.2 | 418.2 | 269.0 | 328.9 | 470.6 | 517.7 |
| 01 | -2.00 | 58.75 | 800.0 | 1.050 | 295.3 | 422.2 | 300.1 | 367.0 | 515.9 | 567.6 |
| 01 | -2.40 | 58.75 | 800.0 | 1.060 | 354.4 | 426.3 | 331.3 | 405.1 | 561.3 | 617.5 |
| 01 | -2.80 | 58.75 | 800.0 | 1.070 | 413.4 | 430.3 | 362.4 | 443.1 | 606.6 | 667.4 |
| 01 | -3.20 | 58.75 | 800.0 | 1.080 | 472.5 | 434.3 | 393.6 | 481.2 | 652.0 | 717.3 |
| 01 | -3.60 | 58.75 | 800.0 | 1.090 | 531.5 | 438.3 | 424.7 | 519.3 | 697.3 | 767.2 |
| 01 | -4.00 | 58.75 | 800.0 | 1.100 | 590.6 | 442.3 | 455.9 | 557.4 | 742.7 | 817.1 |
| 01 | -4.40 | 58.75 | 800.0 | 1.100 | 649.7 | 442.3 | 485.6 | 593.7 | 785.1 | 863.8 |
| 01 | -4.80 | 58.75 | 800.0 | 1.100 | 708.7 | 442.3 | 515.3 | 630.1 | 827.6 | 910.5 |
| 01 | -5.20 | 58.75 | 800.0 | 1.100 | 767.8 | 442.3 | 545.0 | 666.4 | 870.1 | 957.2 |
| 01 | -5.60 | 58.75 | 860.0 | 1.100 | 826.8 | 475.5 | 586.6 | 717.3 | 936.4 | 1030.2 |
| 01 | -6.00 | 58.75 | 1100.0 | 1.100 | 885.9 | 608.2 | 664.0 | 811.8 | 1074.3 | 1181.8 |
| 01 | -6.40 | 58.75 | 1340.0 | 1.096 | 945.0 | 737.9 | 740.2 | 905.1 | 1210.0 | 1331.1 |
| 01 | -6.80 | 58.75 | 1580.0 | 1.086 | 1004.0 | 862.6 | 814.7 | 996.1 | 1342.1 | 1476.5 |
| 01 | -7.00 | 58.75 | 1700.0 | 1.082 | 1033.6 | 924.9 | 851.9 | 1041.7 | 1408.1 | 1549.1 |
| 02 | -7.00 | 90.00 | 2000.0 | 1.070 | 1033.6 | 1075.7 | 906.0 | 1107.9 | 1516.5 | 1668.4 |
| 02 | -7.40 | 90.00 | 2000.0 | 1.080 | 1124.0 | 1085.7 | 955.2 | 1167.9 | 1588.8 | 1747.9 |
| 02 | -7.80 | 90.00 | 2000.0 | 1.090 | 1214.5 | 1095.8 | 1004.3 | 1228.0 | 1661.1 | 1827.4 |
| 02 | -8.20 | 90.00 | 2000.0 | 1.098 | 1305.0 | 1103.8 | 1052.7 | 1287.2 | 1731.9 | 1905.4 |
| 02 | -8.60 | 90.00 | 2000.0 | 1.100 | 1395.5 | 1105.8 | 1098.9 | 1343.7 | 1798.4 | 1978.5 |
| 02 | -9.00 | 90.00 | 2000.0 | 1.100 | 1485.9 | 1105.8 | 1144.4 | 1399.3 | 1863.5 | 2050.1 |
| 02 | -9.40 | 90.00 | 2000.0 | 1.100 | 1576.4 | 1105.8 | 1189.9 | 1455.0 | 1928.6 | 2121.7 |
| 02 | -9.80 | 90.00 | 2000.0 | 1.100 | 1666.9 | 1105.8 | 1235.4 | 1510.6 | 1993.6 | 2193.2 |
| 02 | -10.20 | 90.00 | 2000.0 | 1.100 | 1757.4 | 1105.8 | 1281.0 | 1566.3 | 2058.7 | 2264.8 |
| 02 | -10.60 | 90.00 | 1945.0 | 1.100 | 1847.9 | 1075.4 | 1315.6 | 1608.5 | 2101.8 | 2312.3 |
| 02 | -11.00 | 90.00 | 1725.0 | 1.100 | 1938.3 | 953.8 | 1317.4 | 1610.8 | 2079.4 | 2287.7 |
| 02 | -11.40 | 90.00 | 1505.0 | 1.100 | 2028.8 | 832.1 | 1319.2 | 1613.0 | 2057.0 | 2263.0 |
| 02 | -11.80 | 90.00 | 1285.0 | 1.100 | 2119.3 | 710.5 | 1321.1 | 1615.3 | 2034.6 | 2238.4 |
| 02 | -12.00 | 90.00 | 1175.0 | 1.100 | 2164.5 | 649.7 | 1322.0 | 1616.4 | 2023.4 | 2226.0 |
| 03 | -12.00 | 51.09 | 900.0 | 1.150 | 2164.5 | 520.2 | 1275.5 | 1559.6 | 1930.4 | 2123.7 |
| 03 | -12.40 | 51.09 | 900.0 | 1.150 | 2215.9 | 520.2 | 1301.4 | 1591.2 | 1967.3 | 2164.3 |
| 03 | -12.80 | 51.09 | 900.0 | 1.150 | 2267.3 | 520.2 | 1327.2 | 1622.7 | 2004.2 | 2204.9 |
| 03 | -13.20 | 51.09 | 900.0 | 1.150 | 2318.6 | 520.2 | 1353.0 | 1654.3 | 2041.1 | 2245.5 |
| 03 | -13.60 | 51.09 | 900.0 | 1.150 | 2370.0 | 520.2 | 1378.9 | 1685.9 | 2078.1 | 2286.2 |
| 03 | -14.00 | 51.09 | 900.0 | 1.150 | 2421.3 | 520.2 | 1404.7 | 1717.5 | 2115.0 | 2326.8 |
| 03 | -14.40 | 51.09 | 900.0 | 1.150 | 2472.7 | 520.2 | 1430.5 | 1749.1 | 2151.9 | 2367.4 |
| 03 | -14.80 | 51.09 | 900.0 | 1.150 | 2524.0 | 520.2 | 1456.4 | 1780.7 | 2188.8 | 2408.0 |
| 03 | -15.20 | 51.09 | 900.0 | 1.150 | 2575.4 | 520.2 | 1482.2 | 1812.3 | 2225.8 | 2448.7 |
| 03 | -15.60 | 51.09 | 900.0 | 1.150 | 2626.8 | 520.2 | 1508.0 | 1843.8 | 2262.7 | 2489.3 |
| 03 | -16.00 | 51.09 | 900.0 | 1.150 | 2678.1 | 520.2 | 1533.9 | 1875.4 | 2299.6 | 2529.9 |
| 03 | -16.40 | 51.09 | 900.0 | 1.150 | 2729.5 | 520.2 | 1559.7 | 1907.0 | 2336.6 | 2570.5 |
| 03 | -16.80 | 51.09 | 900.0 | 1.150 | 2780.8 | 520.2 | 1585.5 | 1938.6 | 2373.5 | 2611.2 |
| 03 | -17.20 | 51.09 | 900.0 | 1.150 | 2832.2 | 520.2 | 1611.4 | 1970.2 | 2410.4 | 2651.8 |
| 03 | -17.60 | 51.09 | 900.0 | 1.150 | 2883.6 | 520.2 | 1637.2 | 2001.8 | 2447.3 | 2692.4 |
| 03 | -18.00 | 51.09 | 900.0 | 1.150 | 2934.9 | 520.2 | 1663.0 | 2033.4 | 2484.3 | 2733.0 |
| 03 | -18.40 | 51.09 | 900.0 | 1.150 | 2986.3 | 520.2 | 1688.9 | 2064.9 | 2521.2 | 2773.7 |
| 03 | -18.80 | 51.09 | 1095.0 | 1.150 | 3037.6 | 633.0 | 1755.2 | 2146.0 | 2639.2 | 2903.4 |
| 03 | -19.20 | 51.09 | 1355.0 | 1.150 | 3089.0 | 783.3 | 1835.0 | 2243.6 | 2784.2 | 3063.0 |
| 03 | -19.60 | 51.09 | 1615.0 | 1.150 | 3140.4 | 933.6 | 1914.7 | 2341.1 | 2929.1 | 3222.5 |
| 03 | -20.00 | 51.09 | 1875.0 | 1.144 | 3191.7 | 1078.2 | 1992.5 | 2436.2 | 3070.1 | 3377.5 |
| 03 | -20.00 | 51.09 | 1875.0 | 1.144 | 3191.7 | 1078.2 | 1992.5 | 2436.2 | 3070.1 | 3377.5 |
| 04 | -20.00 | 146.20 | 2200.0 | 1.368 | 3191.7 | 1513.0 | 2148.6 | 2627.1 | 3382.7 | 3721.4 |
| 04 | -20.40 | 146.20 | 2200.0 | 1.395 | 3338.7 | 1542.4 | 2233.1 | 2730.4 | 3509.5 | 3860.9 |
| 04 | -20.80 | 146.20 | 2200.0 | 1.421 | 3485.7 | 1571.8 | 2317.6 | 2833.7 | 3636.3 | 4000.5 |
| 04 | -21.20 | 146.20 | 2200.0 | 1.448 | 3632.6 | 1601.2 | 2402.1 | 2937.0 | 3763.1 | 4140.0 |
| 04 | -21.60 | 146.20 | 2200.0 | 1.450 | 3779.6 | 1603.5 | 2476.8 | 3028.4 | 3870.4 | 4258.0 |
| 04 | -21.80 | 146.20 | 2200.0 | 1.450 | 3852.1 | 1603.5 | 2513.3 | 3073.0 | 3922.6 | 4315.4 |

This time, the formatted results provide the previous results up to the depth for which the stress on the pile section reaches 5 MPa, i.e. a load Q = 5 MPa * $S_{pile}$ ≈ 2.51 MN.

The bearing capacity at $SLS_{qp}$ reaches this value for a pile embedded at elevation -21.80. It is therefore pointless to deepen the piles beyond this depth, because the limiting factor will then be the strength of the concrete and no longer the bearing capacity of the foundation.

*Results tables*

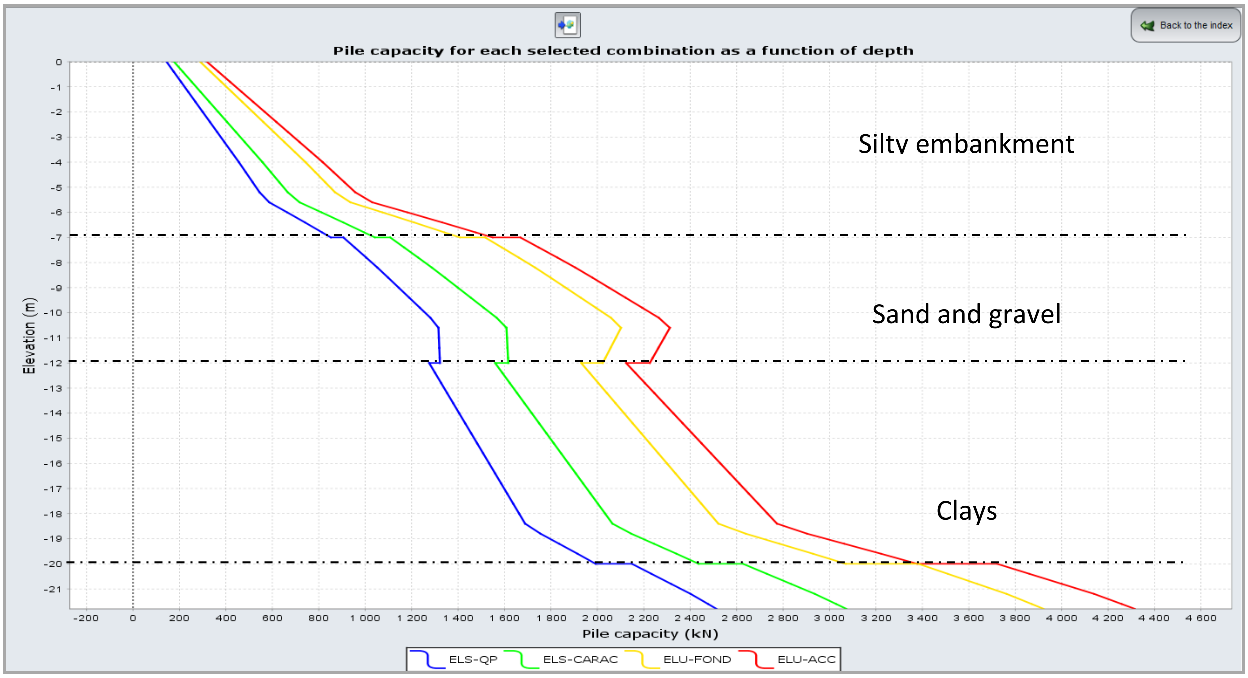
Export | Back to the index

Results

| z | $q_{sl}$ | $q_{pl}$ | QS | QP | Q-ELS-QP | Q-ELS-CARAC | Q-ELU-FOND | Q-ELU-ACC |
|---|---|---|---|---|---|---|---|---|
| -8,600 | 90,00 | 2200,00 | 1395,5 | 1105,8 | 1098,9 | 1343,7 | 1798,5 | 1978,6 |
| -9,000 | 90,00 | 2200,00 | 1486,0 | 1105,8 | 1144,4 | 1399,3 | 1863,5 | 2050,1 |
| -9,400 | 90,00 | 2200,00 | 1576,5 | 1105,8 | 1190,0 | 1455,0 | 1928,6 | 2121,7 |
| -9,800 | 90,00 | 2200,00 | 1666,9 | 1105,8 | 1235,5 | 1510,6 | 1993,6 | 2193,3 |
| -10,200 | 90,00 | 2200,00 | 1757,4 | 1105,8 | 1281,0 | 1566,3 | 2058,7 | 2264,8 |
| -10,600 | 90,00 | 2139,50 | 1847,9 | 1075,4 | 1315,6 | 1608,6 | 2101,9 | 2312,3 |
| -11,000 | 90,00 | 1897,50 | 1938,4 | 953,8 | 1317,4 | 1610,8 | 2079,5 | 2287,7 |
| -11,400 | 90,00 | 1655,50 | 2028,8 | 832,1 | 1319,2 | 1613,0 | 2057,0 | 2263,0 |
| -11,800 | 90,00 | 1413,50 | 2119,3 | 710,5 | 1321,1 | 1615,3 | 2034,6 | 2238,4 |
| -12,000 | 90,00 | 1292,50 | 2164,6 | 649,7 | 1322,0 | 1616,4 | 2023,4 | 2226,1 |
| -12,000 | 51,09 | 1035,00 | 2164,6 | 520,2 | 1275,5 | 1559,6 | 1930,4 | 2123,7 |
| -12,400 | 51,09 | 1035,00 | 2215,9 | 520,2 | 1301,4 | 1591,2 | 1967,3 | 2164,3 |
| -12,800 | 51,09 | 1035,00 | 2267,3 | 520,2 | 1327,2 | 1622,8 | 2004,2 | 2204,9 |
| -13,200 | 51,09 | 1035,00 | 2318,6 | 520,2 | 1353,0 | 1654,4 | 2041,2 | 2245,6 |
| -13,600 | 51,09 | 1035,00 | 2370,0 | 520,2 | 1378,9 | 1685,9 | 2078,1 | 2286,2 |
| -14,000 | 51,09 | 1035,00 | 2421,4 | 520,2 | 1404,7 | 1717,5 | 2115,0 | 2326,8 |
| -14,400 | 51,09 | 1035,00 | 2472,7 | 520,2 | 1430,5 | 1749,1 | 2151,9 | 2367,4 |
| -14,800 | 51,09 | 1035,00 | 2524,1 | 520,2 | 1456,4 | 1780,7 | 2188,9 | 2408,1 |
| -15,200 | 51,09 | 1035,00 | 2575,4 | 520,2 | 1482,2 | 1812,3 | 2225,8 | 2448,7 |
| -15,600 | 51,09 | 1035,00 | 2626,8 | 520,2 | 1508,1 | 1843,9 | 2262,7 | 2489,3 |
| -16,000 | 51,09 | 1035,00 | 2678,2 | 520,2 | 1533,9 | 1875,5 | 2299,7 | 2529,9 |
| -16,400 | 51,09 | 1035,00 | 2729,5 | 520,2 | 1559,7 | 1907,1 | 2336,6 | 2570,6 |
| -16,800 | 51,09 | 1035,00 | 2780,9 | 520,2 | 1585,6 | 1938,6 | 2373,5 | 2611,2 |
| -17,200 | 51,09 | 1035,00 | 2832,3 | 520,2 | 1611,4 | 1970,2 | 2410,4 | 2651,8 |
| -17,600 | 51,09 | 1035,00 | 2883,6 | 520,2 | 1637,2 | 2001,8 | 2447,4 | 2692,5 |
| -18,000 | 51,09 | 1035,00 | 2935,0 | 520,2 | 1663,1 | 2033,4 | 2484,3 | 2733,1 |
| -18,400 | 51,09 | 1035,00 | 2986,3 | 520,2 | 1688,9 | 2065,0 | 2521,2 | 2773,7 |
| -18,800 | 51,09 | 1259,20 | 3037,7 | 633,0 | 1755,2 | 2146,1 | 2639,2 | 2903,5 |
| -19,200 | 51,09 | 1558,20 | 3089,1 | 783,3 | 1835,0 | 2243,6 | 2784,2 | 3063,0 |
| -19,600 | 51,09 | 1857,20 | 3140,4 | 933,6 | 1914,8 | 2341,2 | 2929,2 | 3222,5 |
| -20,000 | 51,09 | 2145,00 | 3191,8 | 1078,2 | 1992,5 | 2436,3 | 3070,1 | 3377,6 |
| -20,000 | 51,09 | 2145,00 | 3191,8 | 1078,2 | 1992,5 | 2436,3 | 3070,1 | 3377,6 |
| -20,000 | 146,20 | 3010,00 | 3191,8 | 1513,0 | 2148,6 | 2627,1 | 3382,7 | 3721,5 |
| -20,400 | 146,20 | 3068,50 | 3338,8 | 1542,4 | 2233,1 | 2730,4 | 3509,6 | 3861,0 |
| -20,800 | 146,20 | 3127,00 | 3485,7 | 1571,8 | 2317,6 | 2833,7 | 3636,4 | 4000,5 |
| -21,200 | 146,20 | 3185,50 | 3632,7 | 1601,2 | 2402,1 | 2937,0 | 3763,2 | 4140,0 |
| -21,600 | 146,20 | 3190,00 | 3779,7 | 1603,5 | 2476,8 | 3028,4 | 3870,5 | 4258,1 |
| -21,797 | 146,20 | 3190,00 | 3852,1 | 1603,5 | 2513,3 | 3073,0 | 3922,6 | 4315,4 |

Similarly, the results table this time provides the previous results down to the depth of 21.80 m.

<u>"Graphical results" frame</u>

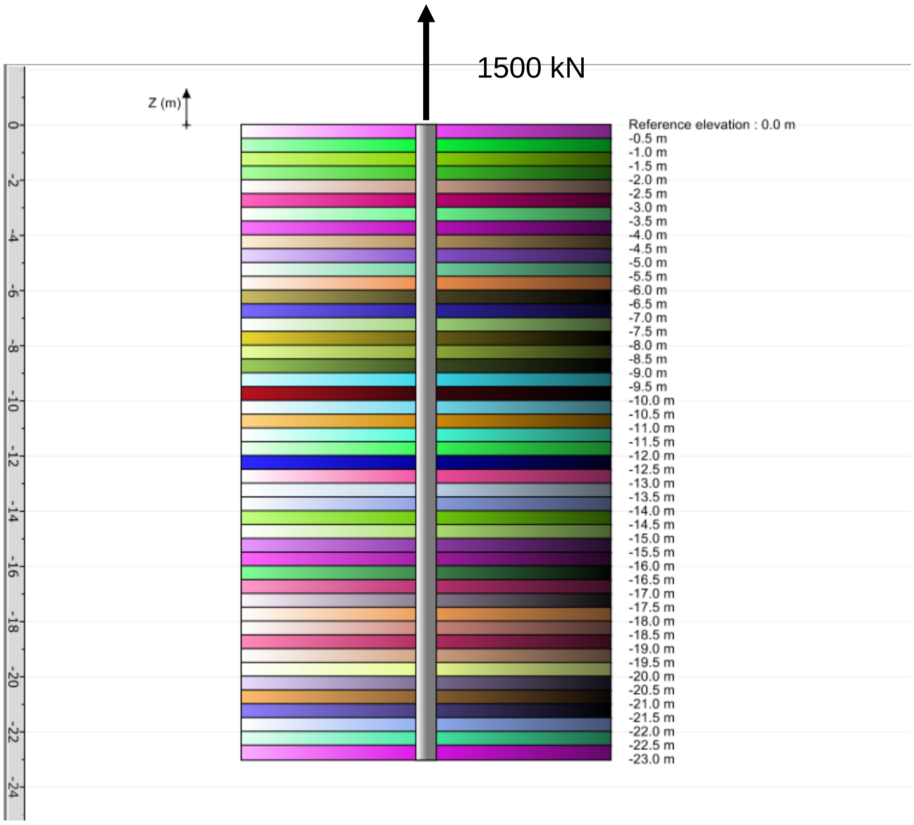



Similarly, the graph of bearing capacities provides the previous results down to the depth of 21.80 m.

### K.4.2. Example 2

This example deals with the case of an HEA 800 section (h = 0.8 m and b = 0.3 m) driven into sand and working in traction. The soil data are taken from the CPT (static penetrometer) results and will be imported from an Excel® file.

The imposed load at pile head is 1500 kN in traction, in Fundamental ULS combination.




#### K.4.2.1. Data input

- Choose to create a new project, by selecting the New project radio button;
- Click the OK button.

If Foxta is already open, click the "File" menu, "New project".

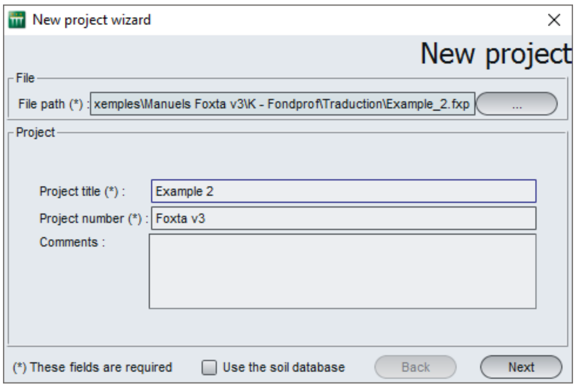
##### K.4.2.1.1. New Project Wizard

<u>"File" frame:</u>

- Fill out the file path by clicking the ... button;
- Give the file a name and save it.

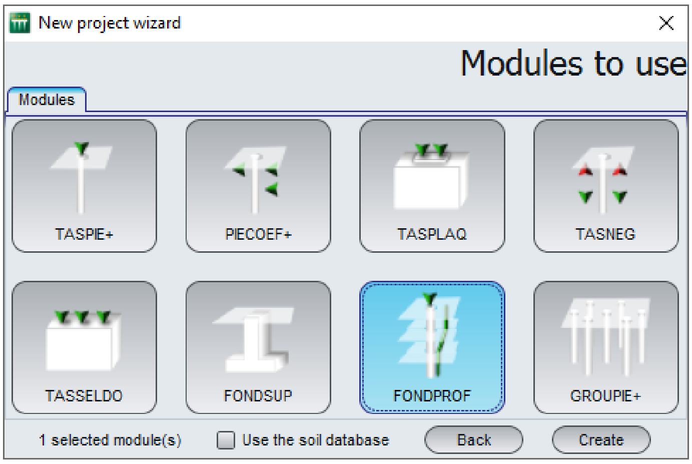
<u>"Project" frame</u>:

- Give the project a title;
- Enter a project number;
- Enter a comment if necessary;
- Leave the "Use soil database" box unticked (we will not use the database for this example) and click the Next button.




### K.4.2.1.2. New Project wizard: choice of module

Select the FONDPROF module, then click the   button.




The FONDPROF data input window appears. The various data tabs must now be filled out.

### K.4.2.2. "Parameters" tab

This tab comprises three frames used to define the general calculation parameters.

<u>"Calculation context" frame</u>:

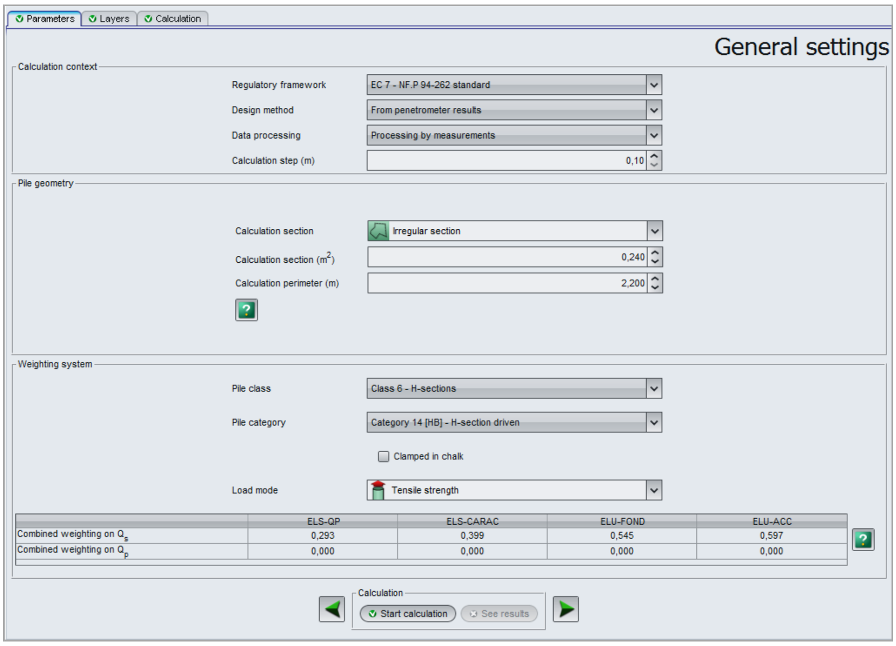
- Regulatory framework: EC7 – Standard NF.P 94-262;
- Design method: From penetrometer results;
- Data processing: Processing by measurements (see example 1 for more details on this choice);
- Calculation step (m): 0.10.

<u>"Pile geometry" frame</u>:

- Calculation section: Irregular calculation section (an HEA 800 section);
- Calculation section ($m^2$): 0.240 (we use the complete area of the section);
- Calculation perimeter (m): 2.20 (we use the total perimeter of the section).

Note: the section will not be used in the calculation for this example, because the pile is traction.

The "Calculation section" help diagram is accessible by clicking the  button (see example 1).




<u>"Weighting system" frame</u>:

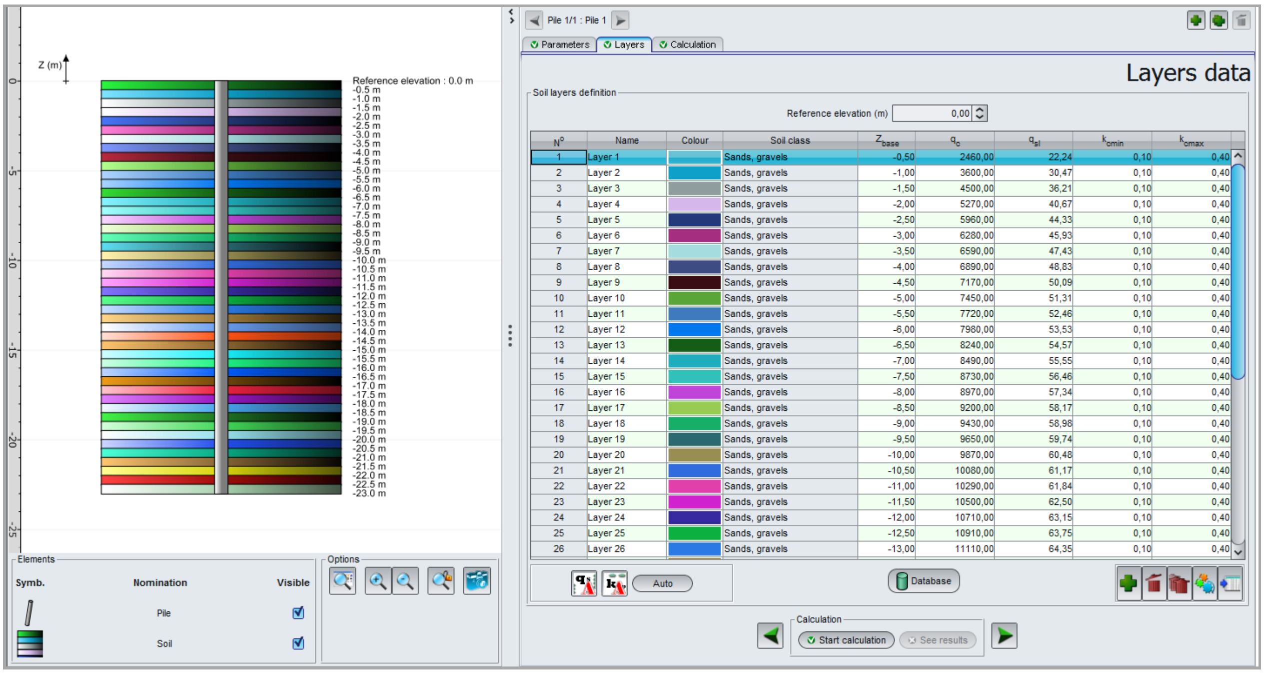
- Pile class: 6 – H-section;
- Pile category : 14 [HB] – H-section driven;
- Embedment in chalk: unticked;
- Load mode: Tensile strength.

The combined weightings on $Q_s$ and $Q_p$ appear at the bottom of this frame (the button next to the table is used to display the project weighting details).

To move onto the next tab, click either the name of the "Layers" tab, or the button.

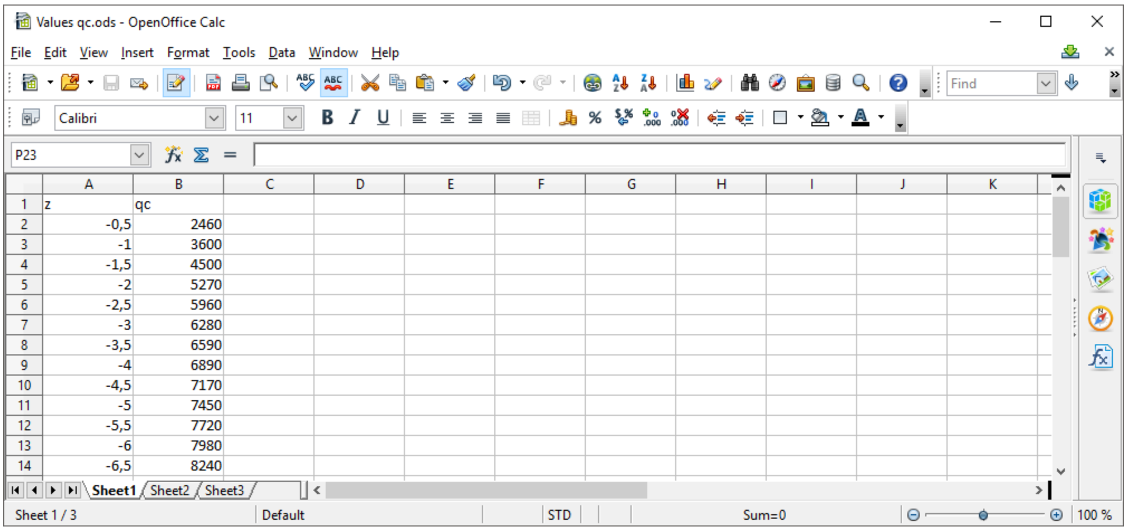
### K.4.2.3. "Layers" tab

This tab is used to define the reference elevation and the various soil layers.



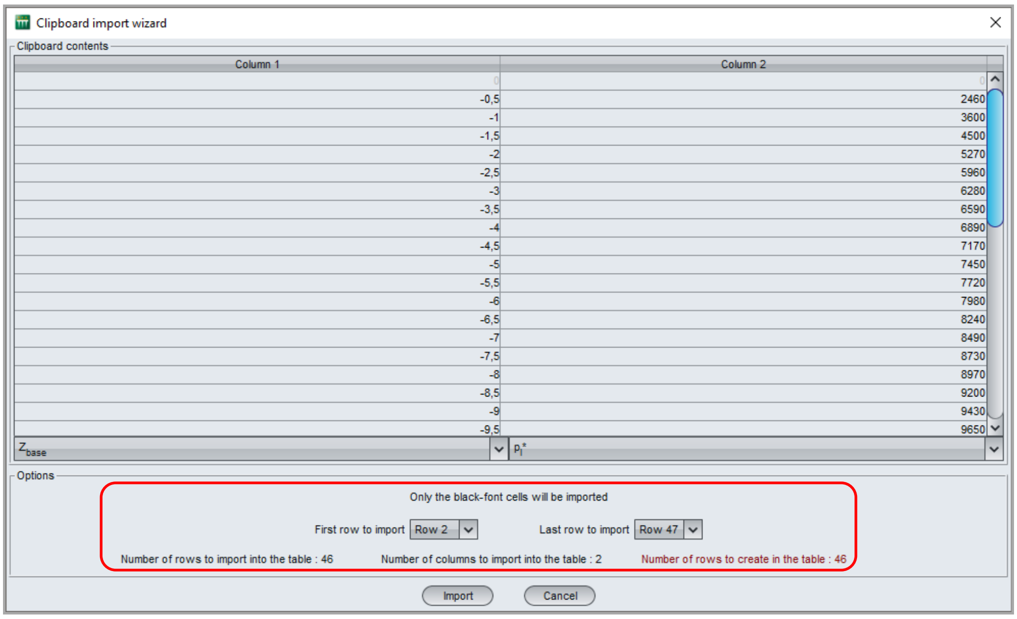
The characteristics of the layers are assumed to be the "raw" results of CPT measurements. We have 46 measurement points down to a depth of 23 m, which will entail the creation of 46 soil "layers" (in practice, it could be many more).

We will import the soil characteristics (CPT) from an Excel® spreadsheet ('Valeurs qc.xls') containing these raw test results: see following screenshot.

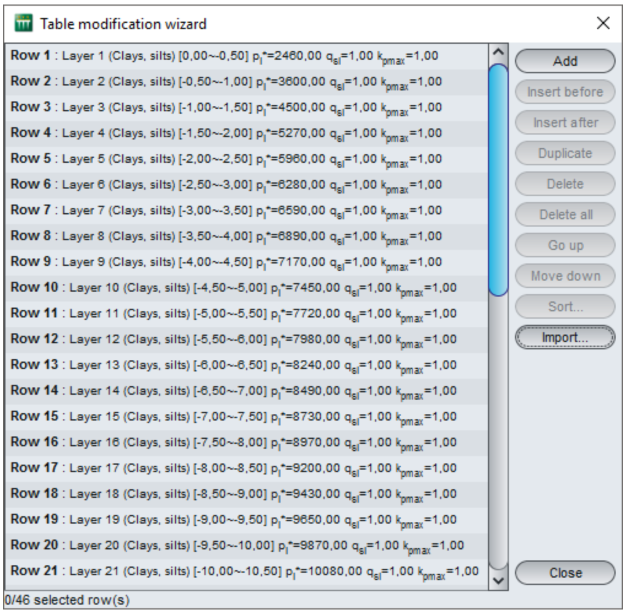



<u>"Soil layers definition" frame</u>:

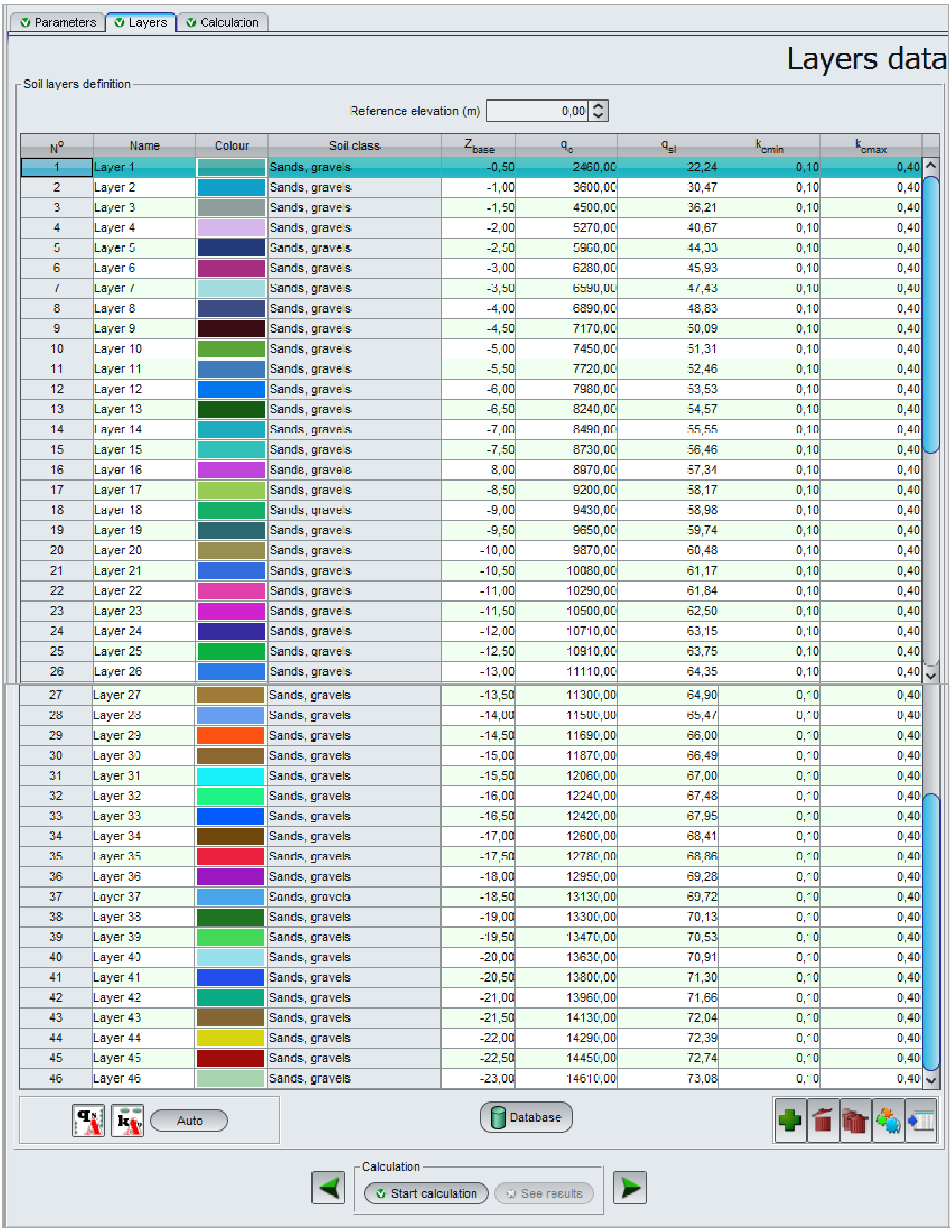
- Input the reference elevation (m): 0.00;
- To import the 46 soil "layers", we will proceed as follows:
  - ➢ create the first soil layer "Layer 1" by clicking the button. Select the soil class 'Sand, gravel', which will enable Fondprof to fill out this field automatically for all the other soil layers during import;
  - ➢ open the 'Valeurs qc.xls' file (provided at installation of Foxta v3, in the Examples – Fondprof subdirectory) and copy the data (for this example, copy the data from line 1 to line 47 and columns A and B into the Windows® clipboard);
    - ➢ open the "Table modification wizard" and click the Import... button;
  - ➢ in this wizard, specify that lines 2 to 47 must be imported. The first line comprising the column headers should be ignored;




➢ the table modification wizard displays the imported data. Click the Close button: the 46 soil layers are now created with a default name, the soil class (copied from the first line), the values of $z_{base}$ and $q_c$.




- The values of $q_{sl}$, $k_{cmin}$ and $k_{cmax}$ must now be filled out, in accordance with the table below. To do this, we can use the Auto wizard, which will fill out the values of $q_{sl}$, $k_{cmin}$ and $k_{cmax}$ for all the layers (see following screenshots).




| N° | Name | Colour | Soil class | $Z_{base}$ | $q_c$ | $q_{sl}$ | $k_{cmin}$ | $k_{cmax}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | Layer 1 | | Sands, gravels | -0,50 | 2460,00 | 22,24 | 0,10 | 0,40 |
| 2 | Layer 2 | | Sands, gravels | -1,00 | 3600,00 | 30,47 | 0,10 | 0,40 |
| 3 | Layer 3 | | Sands, gravels | -1,50 | 4500,00 | 36,21 | 0,10 | 0,40 |
| 4 | Layer 4 | | Sands, gravels | -2,00 | 5270,00 | 40,67 | 0,10 | 0,40 |
| 5 | Layer 5 | | Sands, gravels | -2,50 | 5960,00 | 44,33 | 0,10 | 0,40 |
| 6 | Layer 6 | | Sands, gravels | -3,00 | 6280,00 | 45,93 | 0,10 | 0,40 |
| 7 | Layer 7 | | Sands, gravels | -3,50 | 6590,00 | 47,43 | 0,10 | 0,40 |
| 8 | Layer 8 | | Sands, gravels | -4,00 | 6890,00 | 48,83 | 0,10 | 0,40 |
| 9 | Layer 9 | | Sands, gravels | -4,50 | 7170,00 | 50,09 | 0,10 | 0,40 |
| 10 | Layer 10 | | Sands, gravels | -5,00 | 7450,00 | 51,31 | 0,10 | 0,40 |
| 11 | Layer 11 | | Sands, gravels | -5,50 | 7720,00 | 52,46 | 0,10 | 0,40 |
| 12 | Layer 12 | | Sands, gravels | -6,00 | 7980,00 | 53,53 | 0,10 | 0,40 |
| 13 | Layer 13 | | Sands, gravels | -6,50 | 8240,00 | 54,57 | 0,10 | 0,40 |
| 14 | Layer 14 | | Sands, gravels | -7,00 | 8490,00 | 55,55 | 0,10 | 0,40 |
| 15 | Layer 15 | | Sands, gravels | -7,50 | 8730,00 | 56,46 | 0,10 | 0,40 |
| 16 | Layer 16 | | Sands, gravels | -8,00 | 8970,00 | 57,34 | 0,10 | 0,40 |
| 17 | Layer 17 | | Sands, gravels | -8,50 | 9200,00 | 58,17 | 0,10 | 0,40 |
| 18 | Layer 18 | | Sands, gravels | -9,00 | 9430,00 | 58,98 | 0,10 | 0,40 |
| 19 | Layer 19 | | Sands, gravels | -9,50 | 9650,00 | 59,74 | 0,10 | 0,40 |
| 20 | Layer 20 | | Sands, gravels | -10,00 | 9870,00 | 60,48 | 0,10 | 0,40 |
| 21 | Layer 21 | | Sands, gravels | -10,50 | 10080,00 | 61,17 | 0,10 | 0,40 |
| 22 | Layer 22 | | Sands, gravels | -11,00 | 10290,00 | 61,84 | 0,10 | 0,40 |
| 23 | Layer 23 | | Sands, gravels | -11,50 | 10500,00 | 62,50 | 0,10 | 0,40 |
| 24 | Layer 24 | | Sands, gravels | -12,00 | 10710,00 | 63,15 | 0,10 | 0,40 |
| 25 | Layer 25 | | Sands, gravels | -12,50 | 10910,00 | 63,75 | 0,10 | 0,40 |
| 26 | Layer 26 | | Sands, gravels | -13,00 | 11110,00 | 64,35 | 0,10 | 0,40 |
| 27 | Layer 27 | | Sands, gravels | -13,50 | 11300,00 | 64,90 | 0,10 | 0,40 |
| 28 | Layer 28 | | Sands, gravels | -14,00 | 11500,00 | 65,47 | 0,10 | 0,40 |
| 29 | Layer 29 | | Sands, gravels | -14,50 | 11690,00 | 66,00 | 0,10 | 0,40 |
| 30 | Layer 30 | | Sands, gravels | -15,00 | 11870,00 | 66,49 | 0,10 | 0,40 |
| 31 | Layer 31 | | Sands, gravels | -15,50 | 12060,00 | 67,00 | 0,10 | 0,40 |
| 32 | Layer 32 | | Sands, gravels | -16,00 | 12240,00 | 67,48 | 0,10 | 0,40 |
| 33 | Layer 33 | | Sands, gravels | -16,50 | 12420,00 | 67,95 | 0,10 | 0,40 |
| 34 | Layer 34 | | Sands, gravels | -17,00 | 12600,00 | 68,41 | 0,10 | 0,40 |
| 35 | Layer 35 | | Sands, gravels | -17,50 | 12780,00 | 68,86 | 0,10 | 0,40 |
| 36 | Layer 36 | | Sands, gravels | -18,00 | 12950,00 | 69,28 | 0,10 | 0,40 |
| 37 | Layer 37 | | Sands, gravels | -18,50 | 13130,00 | 69,72 | 0,10 | 0,40 |
| 38 | Layer 38 | | Sands, gravels | -19,00 | 13300,00 | 70,13 | 0,10 | 0,40 |
| 39 | Layer 39 | | Sands, gravels | -19,50 | 13470,00 | 70,53 | 0,10 | 0,40 |
| 40 | Layer 40 | | Sands, gravels | -20,00 | 13630,00 | 70,91 | 0,10 | 0,40 |
| 41 | Layer 41 | | Sands, gravels | -20,50 | 13800,00 | 71,30 | 0,10 | 0,40 |
| 42 | Layer 42 | | Sands, gravels | -21,00 | 13960,00 | 71,66 | 0,10 | 0,40 |
| 43 | Layer 43 | | Sands, gravels | -21,50 | 14130,00 | 72,04 | 0,10 | 0,40 |
| 44 | Layer 44 | | Sands, gravels | -22,00 | 14290,00 | 72,39 | 0,10 | 0,40 |
| 45 | Layer 45 | | Sands, gravels | -22,50 | 14450,00 | 72,74 | 0,10 | 0,40 |
| 46 | Layer 46 | | Sands, gravels | -23,00 | 14610,00 | 73,08 | 0,10 | 0,40 |

The $q_s$ and $k_p$ wizards are also accessible by clicking the ,  buttons.

### K.4.2.4. "Calculation" tab

This calculation is made with an imposed load at pile head of 1500 kN in the ULS-Fundamental combination:

- calculation criterion: imposed load at pile head;
- load at pile head (kN): 1500 (in traction);
- criterion applied to the combination: ULS-FOND.


### K.4.2.5. Calculations and results

#### K.4.2.5.1. Calculations

Until all the tabs are correctly filled out, the button used to start the calculation is marked with a red cross: Start calculation.

Once all the data have been correctly input, the Start calculation button (accessible from all the tabs) becomes active.

Clicking this button will start the calculation.

To access the results in the form of tables and graphics, click the See results button.

## K.4.2.5.2. Results

Formatted results

Options du calcul :
- calcul basé sur des paramètres issus du pénétromètre statique
- calcul selon les règles de la norme NF P 94 262
- profil de contrainte de pointe qc défini par point de mesure
- pour pieu de catégorie : 14
- pour pieu travaillant en traction

| Combinaisons | ELS-QP | ELS-CARA | ELU-FOND | ELU-ACC |
|---|---|---|---|---|
| Frottement | 0.293 | 0.399 | 0.545 | 0.597 |
| Pointe | 0.000 | 0.000 | 0.000 | 0.000 |

Cote de référence : 0.000

Section du pieu : 0.240
Périmètre : 2.200

Caractéristiques des couches (données utilisateur)

| couche | base | qc | qsl | kcmin | kcmax |
|---|---|---|---|---|---|
| 01 | -0.50 | 2460.0 | 22.24 | 0.10 | 0.40 |
| 02 | -1.00 | 3600.0 | 30.47 | 0.10 | 0.40 |

**************
***SOLUTION***
**************

Calcul à charge imposée : Q = 1500.0 vis à vis de la combinaison : ELU-FOND

| couche | cote | qsl | qce | kc | Qs | Qp | ELS-QP | ELS-CARA | ELU-FOND | ELU-ACC |
|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 0.00 | 22.24 | 3180.0 | 0.100 | 0.0 | 76.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| 01 | -0.10 | 22.24 | 3267.3 | 0.108 | 4.9 | 84.8 | 1.4 | 2.0 | 2.7 | 2.9 |
| 01 | -0.20 | 22.24 | 3353.4 | 0.116 | 9.8 | 93.3 | 2.9 | 3.9 | 5.3 | 5.8 |
| 01 | -0.30 | 22.24 | 3438.5 | 0.123 | 14.7 | 101.7 | 4.3 | 5.9 | 8.0 | 8.8 |
| 01 | -0.40 | 22.24 | 3522.7 | 0.130 | 19.6 | 110.2 | 5.7 | 7.8 | 10.7 | 11.7 |
| 01 | -0.50 | 22.24 | 3606.2 | 0.137 | 24.5 | 118.6 | 7.2 | 9.8 | 13.3 | 14.6 |
| 01 | -0.50 | 22.24 | 3606.2 | 0.137 | 24.5 | 118.6 | 7.2 | 9.8 | 13.3 | 14.6 |
| 02 | -0.50 | 30.47 | 3988.3 | 0.133 | 24.5 | 127.8 | 7.2 | 9.8 | 13.3 | 14.6 |
| 02 | -0.60 | 30.47 | 4072.7 | 0.140 | 31.2 | 136.5 | 9.1 | 12.4 | 17.0 | 18.6 |
| 02 | -0.70 | 30.47 | 4155.4 | 0.146 | 37.9 | 145.8 | 11.1 | 15.1 | 20.6 | 22.6 |
| 02 | -0.80 | 30.47 | 4236.4 | 0.153 | 44.6 | 155.6 | 13.1 | 17.8 | 24.3 | 26.6 |
| 02 | -0.90 | 30.47 | 4316.3 | 0.160 | 51.3 | 166.0 | 15.0 | 20.5 | 27.9 | 30.6 |
| 02 | -1.00 | 30.47 | 4395.0 | 0.168 | 58.0 | 177.0 | 17.0 | 23.1 | 31.6 | 34.6 |
| 02 | -1.00 | 30.47 | 4395.0 | 0.168 | 58.0 | 177.0 | 17.0 | 23.1 | 31.6 | 34.6 |
| 03 | -1.00 | 36.21 | 4850.0 | 0.161 | 58.0 | 187.9 | 17.0 | 23.1 | 31.6 | 34.6 |
| 03 | -1.10 | 36.21 | 4921.4 | 0.169 | 65.9 | 199.2 | 19.3 | 26.3 | 35.9 | 39.4 |
| 03 | -1.20 | 36.21 | 4988.1 | 0.176 | 73.9 | 210.9 | 21.7 | 29.5 | 40.3 | 44.1 |
| 03 | -1.30 | 36.21 | 5051.0 | 0.184 | 81.9 | 223.0 | 24.0 | 32.7 | 44.6 | 48.9 |
| 03 | -1.40 | 36.21 | 5110.6 | 0.192 | 89.8 | 235.4 | 26.3 | 35.8 | 49.0 | 53.6 |
| 03 | -1.50 | 36.21 | 5167.5 | 0.200 | 97.8 | 248.3 | 28.7 | 39.0 | 53.3 | 58.4 |
| 03 | -1.50 | 36.21 | 5167.5 | 0.200 | 97.8 | 248.3 | 28.7 | 39.0 | 53.3 | 58.4 |
| 04 | -1.50 | 40.67 | 5540.0 | 0.193 | 97.8 | 257.2 | 28.7 | 39.0 | 53.3 | 58.4 |
| 04 | -1.60 | 40.67 | 5588.2 | 0.202 | 106.8 | 270.3 | 31.3 | 42.6 | 58.2 | 63.7 |
| 04 | -1.70 | 40.67 | 5634.4 | 0.210 | 115.7 | 283.7 | 33.9 | 46.2 | 63.1 | 69.1 |
| 04 | -1.80 | 40.67 | 5678.8 | 0.218 | 124.7 | 297.5 | 36.5 | 49.7 | 67.9 | 74.4 |
| 04 | -1.90 | 40.67 | 5721.9 | 0.227 | 133.6 | 311.7 | 39.1 | 53.3 | 72.8 | 79.8 |
| 04 | -2.00 | 40.67 | 5763.7 | 0.236 | 142.5 | 326.2 | 41.8 | 56.9 | 77.7 | 85.1 |
| 04 | -2.00 | 40.67 | 5763.7 | 0.236 | 142.5 | 326.2 | 41.8 | 56.9 | 77.7 | 85.1 |
| 05 | -2.00 | 44.33 | 6056.7 | 0.229 | 142.5 | 333.2 | 41.8 | 56.9 | 77.7 | 85.1 |
| 05 | -2.10 | 44.33 | 6091.9 | 0.238 | 152.3 | 348.0 | 44.6 | 60.8 | 83.0 | 90.9 |
| 05 | -2.20 | 44.33 | 6126.5 | 0.247 | 162.1 | 363.1 | 47.5 | 64.7 | 88.3 | 96.7 |
| 05 | -2.30 | 44.33 | 6160.6 | 0.256 | 171.8 | 378.5 | 50.3 | 68.6 | 93.6 | 102.6 |
| 05 | -2.40 | 44.33 | 6194.2 | 0.265 | 181.6 | 394.3 | 53.2 | 72.4 | 98.9 | 108.4 |
| 05 | -2.50 | 44.33 | 6227.5 | 0.275 | 191.3 | 410.5 | 56.1 | 76.3 | 104.3 | 114.2 |
| 05 | -2.50 | 44.33 | 6227.5 | 0.275 | 191.3 | 410.5 | 56.1 | 76.3 | 104.3 | 114.2 |
| 06 | -2.50 | 45.93 | 6431.7 | 0.269 | 191.3 | 415.4 | 56.1 | 76.3 | 104.3 | 114.2 |
| 06 | -2.60 | 45.93 | 6462.1 | 0.278 | 201.4 | 431.7 | 59.0 | 80.4 | 109.8 | 120.2 |
| 06 | -2.70 | 45.93 | 6492.2 | 0.288 | 211.5 | 448.2 | 62.0 | 84.4 | 115.3 | 126.3 |
| 06 | -2.80 | 45.93 | 6522.1 | 0.297 | 221.6 | 464.9 | 64.9 | 88.4 | 120.8 | 132.3 |
| 06 | -2.90 | 45.93 | 6551.7 | 0.306 | 231.7 | 481.7 | 67.9 | 92.5 | 126.3 | 138.3 |
| 06 | -3.00 | 45.93 | 6581.2 | 0.316 | 241.8 | 498.7 | 70.9 | 96.5 | 131.8 | 144.4 |
| 06 | -3.00 | 45.93 | 6581.2 | 0.316 | 241.8 | 498.7 | 70.9 | 96.5 | 131.8 | 144.4 |
| 07 | -3.00 | 47.43 | 6735.0 | 0.311 | 241.8 | 502.4 | 70.9 | 96.5 | 131.8 | 144.4 |
| 07 | -3.10 | 47.43 | 6763.9 | 0.320 | 252.3 | 519.5 | 73.9 | 100.7 | 137.5 | 150.6 |
| 07 | -3.20 | 47.43 | 6792.8 | 0.329 | 262.7 | 536.8 | 77.0 | 104.8 | 143.2 | 156.8 |
| 07 | -3.30 | 47.43 | 6821.5 | 0.339 | 273.1 | 554.2 | 80.0 | 109.0 | 148.9 | 163.1 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 40 | -19.60 | 70.91 | 13731.4 | 0.400 | 2483.7 | 1318.2 | 727.7 | 991.0 | 1353.6 | 1482.8 |
| 40 | -19.70 | 70.91 | 13747.8 | 0.400 | 2499.3 | 1319.8 | 732.3 | 997.2 | 1362.1 | 1492.1 |
| 40 | -19.80 | 70.91 | 13764.3 | 0.400 | 2514.9 | 1321.4 | 736.9 | 1003.5 | 1370.6 | 1501.4 |
| 40 | -19.90 | 70.91 | 13780.9 | 0.400 | 2530.5 | 1323.0 | 741.5 | 1009.7 | 1379.1 | 1510.7 |
| 40 | -20.00 | 70.91 | 13797.5 | 0.400 | 2546.1 | 1324.6 | 746.0 | 1015.9 | 1387.7 | 1520.1 |
| 40 | -20.00 | 70.91 | 13797.5 | 0.400 | 2546.1 | 1324.6 | 746.0 | 1015.9 | 1387.7 | 1520.1 |
| 41 | -20.00 | 71.30 | 13880.0 | 0.400 | 2546.1 | 1332.5 | 746.0 | 1015.9 | 1387.7 | 1520.1 |
| 41 | -20.10 | 71.30 | 13896.6 | 0.400 | 2561.8 | 1334.1 | 750.6 | 1022.2 | 1396.2 | 1529.4 |
| 41 | -20.20 | 71.30 | 13913.2 | 0.400 | 2577.5 | 1335.7 | 755.2 | 1028.4 | 1404.7 | 1538.8 |
| 41 | -20.30 | 71.30 | 13929.7 | 0.400 | 2593.2 | 1337.2 | 759.8 | 1034.7 | 1413.3 | 1548.1 |
| 41 | -20.40 | 71.30 | 13946.1 | 0.400 | 2608.9 | 1338.8 | 764.4 | 1040.9 | 1421.8 | 1557.5 |
| 41 | -20.50 | 71.30 | 13962.5 | 0.400 | 2624.6 | 1340.4 | 769.0 | 1047.2 | 1430.4 | 1566.9 |
| 41 | -20.50 | 71.30 | 13962.5 | 0.400 | 2624.6 | 1340.4 | 769.0 | 1047.2 | 1430.4 | 1566.9 |
| 42 | -20.50 | 71.66 | 14045.0 | 0.400 | 2624.6 | 1348.3 | 769.0 | 1047.2 | 1430.4 | 1566.9 |
| 42 | -20.60 | 71.66 | 14061.3 | 0.400 | 2640.3 | 1349.9 | 773.6 | 1053.5 | 1439.0 | 1576.3 |
| 42 | -20.70 | 71.66 | 14077.6 | 0.400 | 2656.1 | 1351.4 | 778.2 | 1059.8 | 1447.6 | 1585.7 |
| 42 | -20.80 | 71.66 | 14093.8 | 0.400 | 2671.9 | 1353.0 | 782.9 | 1066.1 | 1456.2 | 1595.1 |
| 42 | -20.90 | 71.66 | 14110.1 | 0.400 | 2687.6 | 1354.6 | 787.5 | 1072.4 | 1464.8 | 1604.5 |
| 42 | -21.00 | 71.66 | 14126.3 | 0.400 | 2703.4 | 1356.1 | 792.1 | 1078.7 | 1473.4 | 1613.9 |
| 42 | -21.00 | 71.66 | 14126.3 | 0.400 | 2703.4 | 1356.1 | 792.1 | 1078.7 | 1473.4 | 1613.9 |
| 43 | -21.00 | 72.04 | 14208.3 | 0.400 | 2703.4 | 1364.0 | 792.1 | 1078.7 | 1473.4 | 1613.9 |
| 43 | -21.10 | 72.04 | 14224.4 | 0.400 | 2719.3 | 1365.5 | 796.7 | 1085.0 | 1482.0 | 1623.4 |
| 43 | -21.20 | 72.04 | 14240.5 | 0.400 | 2735.1 | 1367.1 | 801.4 | 1091.3 | 1490.6 | 1632.9 |
| 43 | -21.30 | 72.04 | 14256.6 | 0.400 | 2751.0 | 1368.6 | 806.0 | 1097.6 | 1499.3 | 1642.3 |
| 43 | -21.31 | 72.04 | 14258.0 | 0.400 | 2752.3 | 1368.8 | 806.4 | 1098.2 | 1500.0 | 1643.1 |

In the ULS-FOND column, we can see that the load value of 1500 kN in traction is reached at the depth of 21.31 m.

## Superposed bearing capacity curves