
Example nº 13
Pile wailing

CivilFEM Manual of Advanced Examples

Example nº 13 – Table of Contents

- 13 EXAMPLE Nº 13: PILE WAILING 1
 - 13.1 AIM 1
 - 13.2 DESCRIPTION OF THE EXAMPLE 1
 - 13.3 RESULTS TO BE OBTAINED 1
 - 13.4 ANALYTICAL RESOLUTION 2
 - 13.4.1 Pile diameter 2
 - 13.4.2 Pile length 2
 - 13.4.3 Maximum vertical displacement 3
 - 13.5 CALCULATION LOG 4
 - 13.5.1 Introduction 4
 - 13.5.2 Material and terrain generation. 7
 - 13.6 SUMMARY 7

13 EXAMPLE N° 13: PILE WAILING

13.1 AIM

The aim of this example is to show CivilFEM possibilities and applications to:

- Pile wailing design
- Settlement calculation

and how easily to manage with the pile wailing window.

13.2 DESCRIPTION OF THE EXAMPLE

A highway viaduct will be built on tertiary sediment mainly clay/slime with some gravel, and some sand.

A pier will transfer 1500 Tn and we would like a foundation of 5mx10m. The terrain has one layer. In the laboratory tests make it on the sediment we get the following parameters:

Terrain parameters:

- Specific weight: 2.09E4 N/m³.
- q_u : 50E4 N/m².
- NSPT: 46
- Surface level: 0 m

Loads:

- F_z : 1500E4 N.

Geometry:

- Pile wailing: 5.3x5.3x3.3 m³.
- Number of piles: 4
- Separation: 3.6 m
- Pile height: 0.10 m
- Pier: 1x1m².

Structural limit.

- $\sigma_d = 33\text{Kp/cm}^2$.

13.3 RESULTS TO BE OBTAINED

The results to be obtained with the calculation are:

1. Pile diameter.
2. Pile length.

3. Maximum vertical displacement.

13.4 ANALYTICAL RESOLUTION

13.4.1 Pile diameter

To get the area of the piles:

$$N_{pil} = A_{pil} \times \sigma_d$$

So the area is:

$$\frac{1500}{4} = A_{pil} * 330 \quad A_{pil} = 1.136 \text{m}^2$$

And finally we get the diameter:

$$\frac{\pi * \phi^2}{4} = A_{pil} \quad \phi = 1.2 \text{m}$$

13.4.2 Pile length

The unit point resistance it is possible to get by:

$$q_p = 9 \cdot \frac{50}{2} = 225 \text{Mp} / \text{m}^2$$

And the point:

$$Q_p = 225 \cdot \frac{\pi \cdot 1.2^2}{4} = 254.5 \text{Mp}$$

Group effect coefficient.

$$\eta_r^p = 1 - \frac{2}{16} = 0.875$$

$$Q_{pg} = 206.8 \text{Mp}$$

Now the values for the skin of the pile.

$$f_s = \alpha \cdot 25 = 0.36 \cdot 25 = 9.1 \text{Mp} / \text{m}^2$$

$$Q_s = 9.1 \cdot \alpha \cdot 1.2 \cdot \text{Lpil} = 34.3 \cdot \text{Lpil} \cdot \text{Mp}$$

$$Q_{sg} = 27.9 \cdot \text{Lpil} \cdot \text{Mp}$$

With this the length of the piles is.

$$F_s = 1.5 \qquad F_p = 4.0$$

$$\frac{222.7}{4} + \frac{30 \cdot \text{Lpil}}{1.5} = \frac{1500}{4}$$

$$\text{Lpil} = 16$$

13.4.3 Maximum vertical displacement

To calculate the maximum vertical displacement:

$$\eta_w = 2.5 \quad (\text{Cooke})$$

$$Q = 375 \text{Mp} \qquad Q_{sg} = 227.9 \cdot 18 = 502.2 \text{Mp}$$

Before apply the group effect the values are:

$$W_s = 0.01 \cdot 1.2 = 0.012 \text{m}$$

$$W_p = 0.08 \cdot 1.2 = 0.096 \text{m}$$

and after to apply it:

$$W_s^* = 2.5 \cdot 0.012 = 0.03 \text{m}$$

$$W_p^* = 2.5 \cdot 0.096 = 0.24 \text{m}$$

First corner of the curve Q-W:

$$502.2 + \frac{0.03}{0.24} \cdot 206.8 = 528.05 \text{Mp}$$

So the settlement is:

$$W = \frac{375}{528.05} \cdot 0.03 = 0.02$$

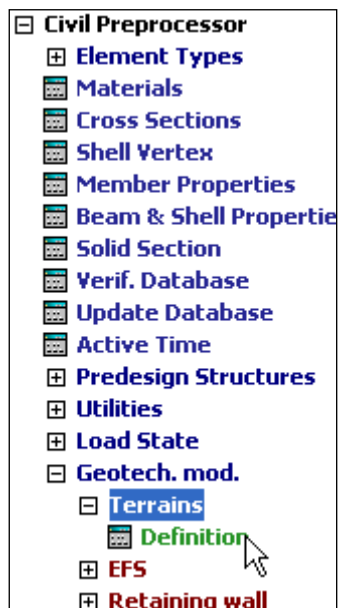
13.5 CALCULATION LOG

13.5.1 Introduction

Geotechnical module has to be activate to use this utility.

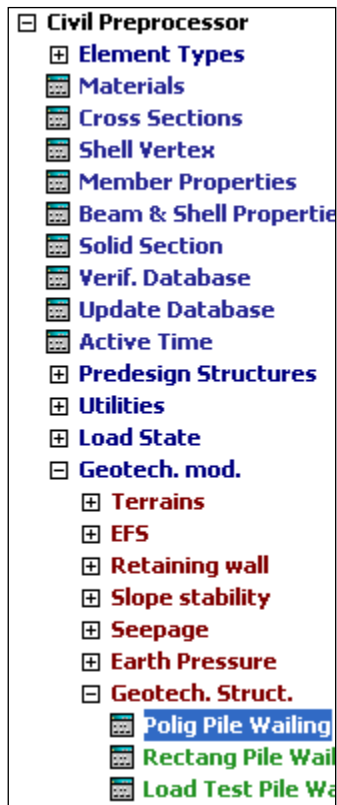
The first step is to define the materials, we need a concrete a reinforcement steel and a material for the terrain. The chosen materials are HA-25 concrete, B500S reinforcement steel, and the soil will be CL. The soil properties must be set.

Then, the terrain must be defined.

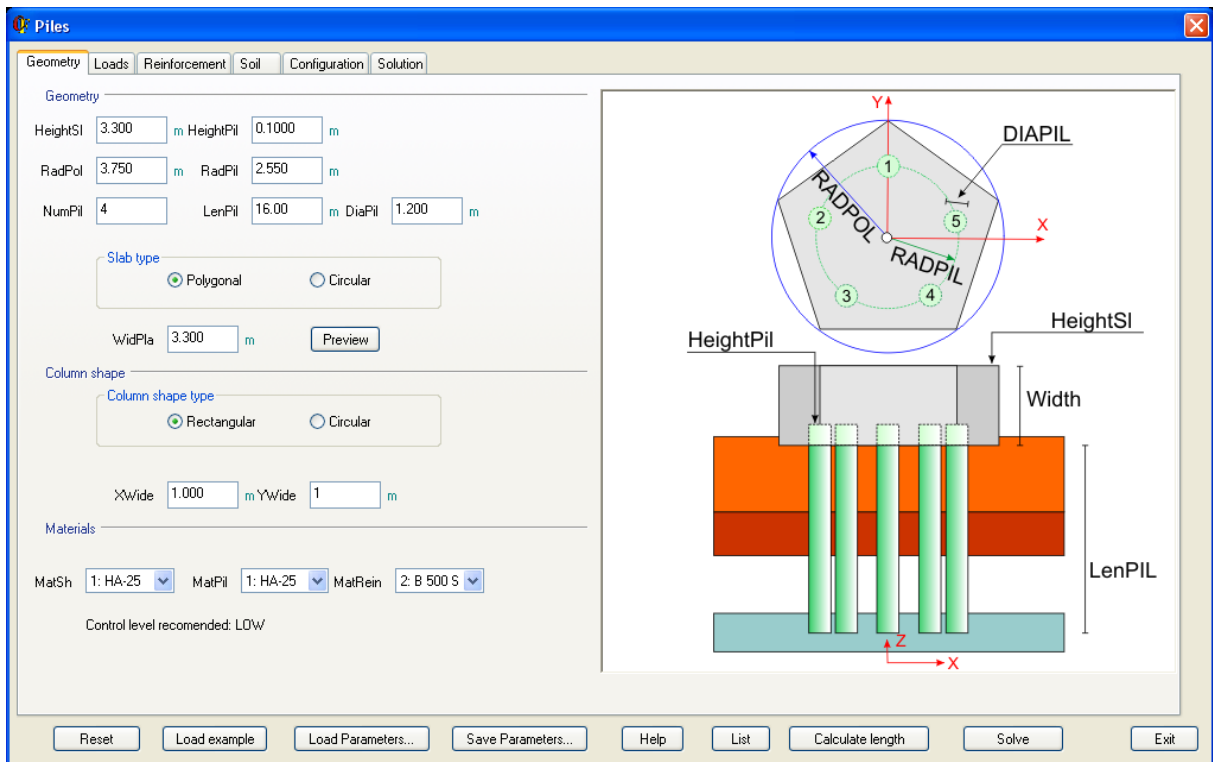


The terrain will only have one layer, so a 50 m thick layer is set and the vertical axis (KeyDir) must be set to Z. Material and Chadeysson ballast module have to be chosen.

The pile wailing geometry is defined using the pile wailing definition window:



In this window the geometry, the loads, the reinforcement, and some additional properties needed for the terrain are defined.



Pile wailing geometry is defined by slab circumscribed circumference radius and piles centres radius which are 3.75 m and 2.55 m respectively.

Once geometry, loads and soil parameters are defined the utility 'Calculate pile length' is launched and CivilFEM will predesign the pile length. Before calculating the pile length, CivilFEM check the Mean Design Stress for the chosen pile diameter according to:

$$\frac{N_{\max}}{\pi \frac{D_P^2}{4}} \leq \sigma_d$$

Where N_{\max} is the axial and σ_d is the structural limit defined at Loads window. If failed, CivilFEM suggests the minimum diameter required. (1.15 metres for this example)

The screenshot shows the 'Pile length' dialog box with the following values:

- Eta coefficients (Subsidence):** $\eta_s = 0.875$, $\eta_p = 0.875$
- Eta coefficient (Settlement):** $\eta_s = 2.496878$, $\eta_p = 2.496878$
- Security factors:** $F_s = 1.5$, $F_p = 4$, $F_l = 1.00$
- Predesigning results:** LenPil = m

Buttons: Calculate, Apply and exit, Cancel

This predesign will give a value of 15 m. A diameter of 1.2 m has been used to get this length.

The 'Apply and exit' button is pressed. Reinforcement and configuration parameters have to be defined and then the 'Solve' button.

13.5.2 Material and terrain generation.

```
! Pile wailing
FINISH
~CFCLEAR,,1
~CFACTIV,GETC,Y
~UNITS,SI
/PREP7

~CFMP,1,LIB,CONCRETE,EHE,HA-25
~CFMP,2,LIB,REINF,EHE,B 500 S
~CFMP,3,LIB,SOIL,,CL
~CFMP,3,SOIL,SPT,,46
~CFMP,3,SOIL,QU,,500000
~CFMP,3,SOIL,PHIMCEFF,,38
~CFMP,3,SOIL,CMCEFF,,60000

~TERDEF,1,NEW,1,0,Z,,,,0,,Soil
~TERDEF,1,LAYER,1,3,50,0,DB,0
```

13.6 SUMMARY

The purpose of this example is to get use to manage with the pile wailing window, and its capabilities.

It is important to point out that it is not necessary a difficult log to make a pile wailing but it is necessary to define **carefully** the materials and the terrains with the capabilities of CivilFEM.