COST GABI \ Working group 4: Thermoactive geostructures design

Benchmark n°1: Modelling Energy Piles

The experimental site is located in the north of France, near Dunkirk. The average annual outside temperature in Dunkirk is 11.3°C.

The soil is mainly made of poorly graded clean sand, which is covered by a layer of silts about 2.7 m thick. The depth of water table is 1.6 m and the average temperature of the soil is around 14°C.

The case study deals with cast flight auger (CFA) piles with a 0.52 m diameter and a 12.0 m length.

The concrete compressive strength is 42 MPa. The reinforced cage is made of 5 steel rods with a 20 mm diameter (see Figures 1a and 1b). The installation parameters are joined in annex.

Two U-loops were installed in each pile (see Figure 1a).



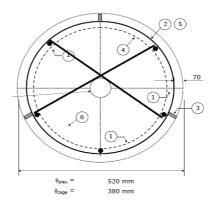


Figure 1a et 1b

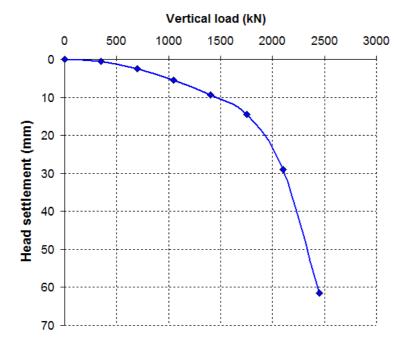
The main properties have been measured until a 15 meters depth and are given on Table 1.

- volumetric weight γ,
- mechanical properties :
 - o shearing resistance measured with a shear-box apparatus on undisturbed samples,
 - CPT and PMT results are given in annex (the different in-situ-tests results are reported in Annex)

Table 1 : Ground model

	Thickness (m)	γ (kN.m-3)	arphi' (kPa)	c' (kPa)
Silt	2,7	19,0	-	-
Poorly graded sand	> 13	19,5	31	2

A static load test with maintained load steps (each of one hour duration) has been performed on a first CFA pile and the significant results are given in Figure 2 and Table 2.



Vertical load (kN)	Head settlement (mm)
0	0
350	0,55
700	2,45
1050	5,4
1400	9,3
1750	14,55
2100	29
2450	61,5

Figure 2 and Table 1

The thermal loading was applied on a second pile similar to the first one. A mechanical preloading equal to 900 kN was maintained during the whole test duration. The value of 900 kN was chosen, corresponding to the typical "working load" under French buildings. A thermal loading was then applied, through imposing the fluid's average temperature (T_{in} - $T_{out} = 3$ °C). It consisted in two weeks long phases, with the following temperature conditions:

- cooling phase : decrease in average temperature of 12°C,
- heating phase: increase in average temperature of 15°C.

The benchmark will focus on the following output parameters:

- head settlement.
- internal stresses or forces,
- mobilised shaft friction and base resistance.

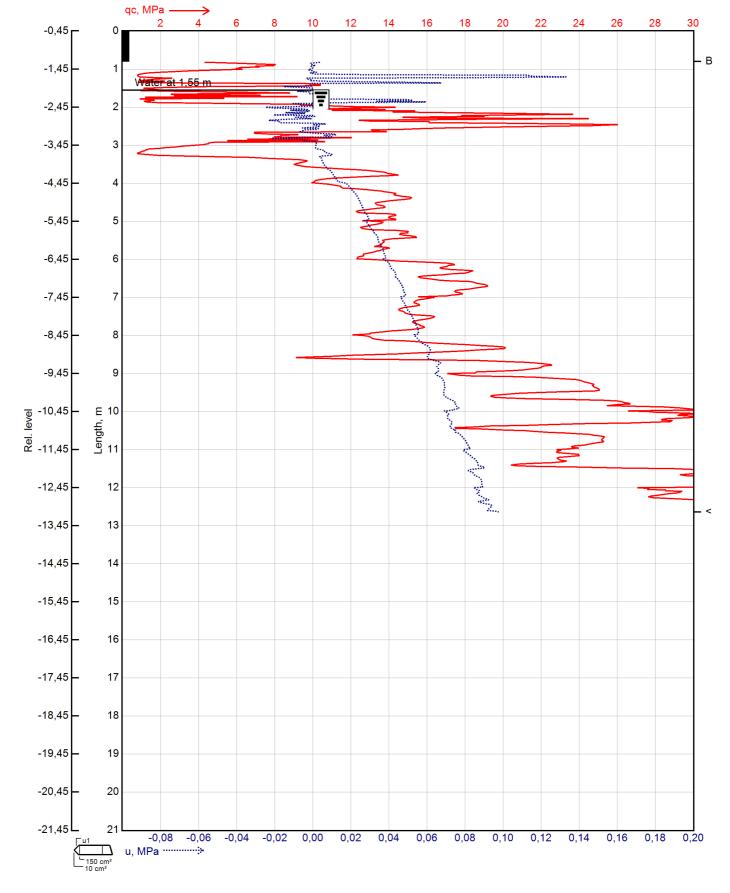
In a second step (without experimental results), the same calculations can be performed for different head rigidity conditions :

- fixed head pile (infinite vertical rigidity),
- vertical rigidity of 100 MN/m.

In a third step, which checks will you perform to design this pile (900 kN is supposed to be the quasi-permanent SLS load)?



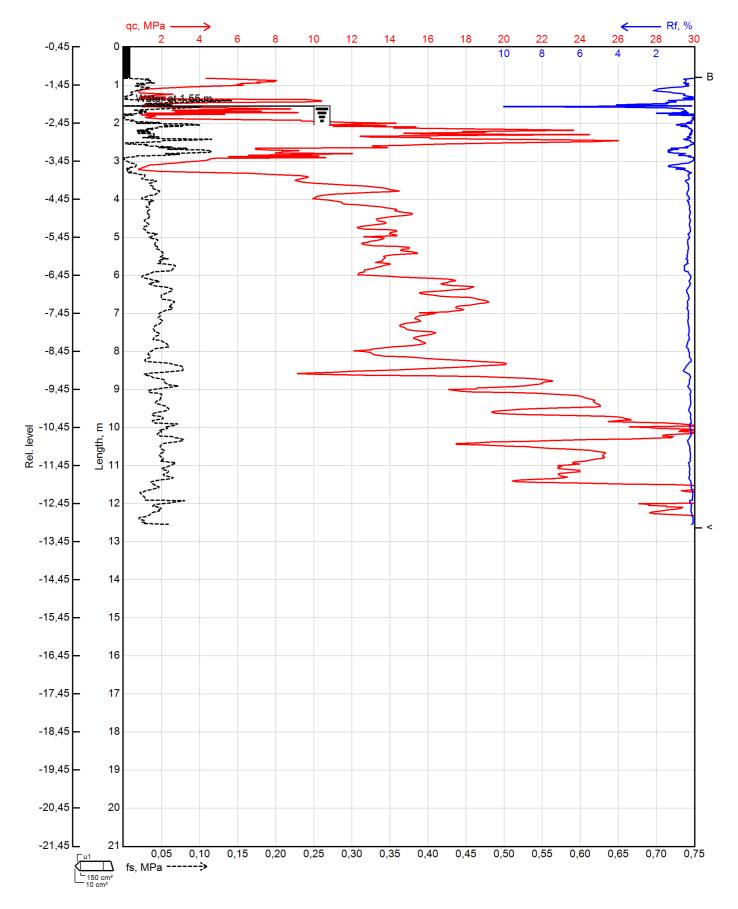
Z1546007 - S03 Execution date: 59210 COUDEKERQUE CPT-U u1 200 kN GRW: Water at 1,55 m

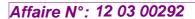




Z1546007 - S03 Execution date:59210 COUDEKERQUE CPT-U u1 200 kN

GRW: Water at 1,55 m







Sondage: PR01

Type: PRESSIOMETRE

Client: IFSTTAR

Etude: IFSTTAR OR Géothermie 2012

Site expèrimental de Coudekerque

Remarque :

X: 602485 Y: 368171 Z: 3,21 m

Echelle: 1/80

Date: 17/10/2012

Début : 0,00

Fin: 15,90

	Ecnelle: 1/80									
Cote NGF	Profondeur (m)	Coupe Sommaire	Wn (%)	Niveau d'eau	DATES	OUTIL	EQUIPEMENT	TUBAGE		Em/Pl*
3-	0.00-	Terre végétale avec remblai de briques.		_			ш		0 1 2 3 4 5	
2-	1.00-	Limon marron-jaune avec traces d'oxydation.		√∫nappe		3 mm			0.3	12.0
1-	2.00-	Limon sableux verdâtre		₩	11/10/12	tarière 63 mm			0.3	6.0
0-	3.00-				_				2.8	5.0
-1-	4.00-								5.1	4.0
-2-	5.00-								5 12.1 1.27	9.0
-3-	6.00-				12/10/12			diam 90 mm	0.6	7.0
-4-	7.00-				12			diam (10.0
-5-	8.00-								8 1.0 2.06	7.0
-6-	9.00-	Sable vert fin.				aillant 55 mm			24.0	9.0
-7-	10.00-				15/10/12	taillant			35.3	15.0
-8-	11.00-				15				33.5	8.0
-9-	12.00-								12 26.7 2.89	9.0
-10-	13.00-				2				13 22.1 3.93	5.0
-11-	14.00-				16/10/12				14 23.3 1.8 3.38	6.0
-12-	15.00 <u> </u>								31.2	8.0
-13-	16.00-								16	

COUDEKERQUE 05 Pieu Contrat: 22805 Date 05/07/13 Diamètre tarière 0.520 mHeure 09h05 Profondeur Pieu 12.20 m Bétonnage : 09h25 Volume Béton 3.39 m3 Fin Pieu 09h34 Surconsommation 34 % Inclinaison X;Y :-9.9:-9.9 VAF: 500 m/h... VAR: 500 m/h... 1/ Profil du Pieu Pres. Betan | VR: 50 t/mn 100 520_mm_ 5_bar. _CR:_400_bar 0 1 2 3 5 6 7 8 9 10 11