Determination of the Typical Profile of the Land and of the Solicitations Acting on the Piles

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Abstract: ***A good knowledge of the global characteristics of the soil is essential in the execution of any civil engineering work. It constitutes, indeed, one of the main elements of the choice of the solution for the crossing. In this respect, it should be emphasized that in the case of current structures, the cost of geotechnical reconnaissance represents a significant percentage of the total cost of the project. The objective of this work is based on the determination of the standard profile of the land to accommodate the structure plans to build and characteristics of different layers of soil for sizing foundations. In this work, we used investigations (Insitu tests) such as: soundings to determine the general characteristics of soil layers such as: position, thickness and homogeneity; likely to be interested in the foundations. The study led to the determination of: The average limit pressure. 2) The average pressure module 3) The typical profile of the land 4) The critical embedding depth of the foundations. 5) The stresses in the piles***

Keywords: Soils; Profile; Deep foundation; Layers; Solicitations; Pious

1. Introduction

Soils are generally discontinuous environments, consisting of juxtaposition of grains of different sizes, natures and shapes. Foundations are defined as the lower or lower part of a structure and they rest on the ground which serves as their seat. The foundations must be able to transmit to the floor all the various loads: fixed, mobile and oscillating; overloads, thrusts (wind, snow, etc.) and reactions (water stresses, vibrations, braking, temperature variation, and shrinkage) to which the structure is subjected. In addition, they must, by virtue of the principle of equal and opposite reaction to the action, withstand the contrary pushes of the ground on which they rest, or which they cross. Where the total resistance of a soil varies with the internal friction of the different layers of the soil, materialized by their natural slope angles and with their cohesions which imply the resistance to shear under a zero load. However, the choice of the type of foundation depends on two factors which are:

- Security
- The economy

It is also a function of the soil recognition and the conditions to be fulfilled. Soil recognition makes it possible to determine the nature of the different layers of the soil encountered by the probes during the soundings and which are intended for the determination of the layer of the bearing soil. Sufficient on which one can found a Work of Art such as: the bridges, the lock, the dams; in addition to aquifers that will have to cross to reach this layer of soil. To achieve this, we conduct surveys such as:

- Carrot soundings
- Pressure meter soundings

In practice, the maximum dimension of the foundation footing (in the case of single soles) is investigated at a depth of three times with a minimum of 6m, and equal to one and a half times the maximum dimension of the total right-of-way (in the case of a foundation with several soles). Indeed in the case of pile foundations as illustrated in our project, the previous depths are reduced by a third from the tip of the pile.

In addition, the soil profile is the set of horizons of a given soil. The soil is also a soft layer, resulting from the degradation of a source rock.

2. Literature Review

A lot of work has been carried out (Huge work done on the determination of the typical profile of the ground and the characteristics of the soil layers) in the study of deep foundations for structures such as bridges. Art building is a word composed of the word building which indicates the constructions and of the word Art which indicates the importance of the esthetic and architectural aspect of these constructions. It is in the field of foundations that engineers encounter the most difficult problems to solve because mistakes that can be made are sometimes difficult, time consuming and expensive to correct, if not impossible. This is why several researchers have carried out studies such as:

Origin of Pathologies, Observations, Diagnosis in Engineering Structures (ITBTP Annals N ° 523)."Technical Rules for the Design and Calculation of Foundations of Civil Engineering Works"."Current Foundations of Structures FOND. 72 »excerpts Leaflet 2-3-4. Apparent effects of concrete structures. Applications of Eurocode 2: calculation of concrete buildings, Press of roads and buildingsRecognition and testing-sampling of soils, rocks-Methodology and Procedures. Geotechnical reconnaissance and testing-Laboratory tests on soils - Part 4: Determination of the particle size distribution.

3. Materials and Methods

The geotechnical reconnaissance is the best possible knowledge, qualitative and quantitative, of the lands concerned by the project, including all the phenomena related to the possible presence of water in the ground. As a result, a methodology must be applied to conduct field and laboratory work well.

a) Fieldwork

The principle of testing is as follows:

- Core sampling and sampling (realize by XP P94-202 standard)
- Pressure sounding (realize according to standard NF P94-110)

b) Materials used

- Sounder: Good Hope B
- APAGEO Barometer "Ménard" type with BX probes
- Double corers with a diameter of 101 mm
- Tricones 63 mm

c) Geographic location

As part of the "A3 Oued Zagar-Bousalem-Lot1: OuedZagar-Rhayette" project, a geotechnical reconnaissance campaign was carried out by GETU. This report records all the results of the "Insitu" investigations (pressure and core drilling) carried out under GOH16.

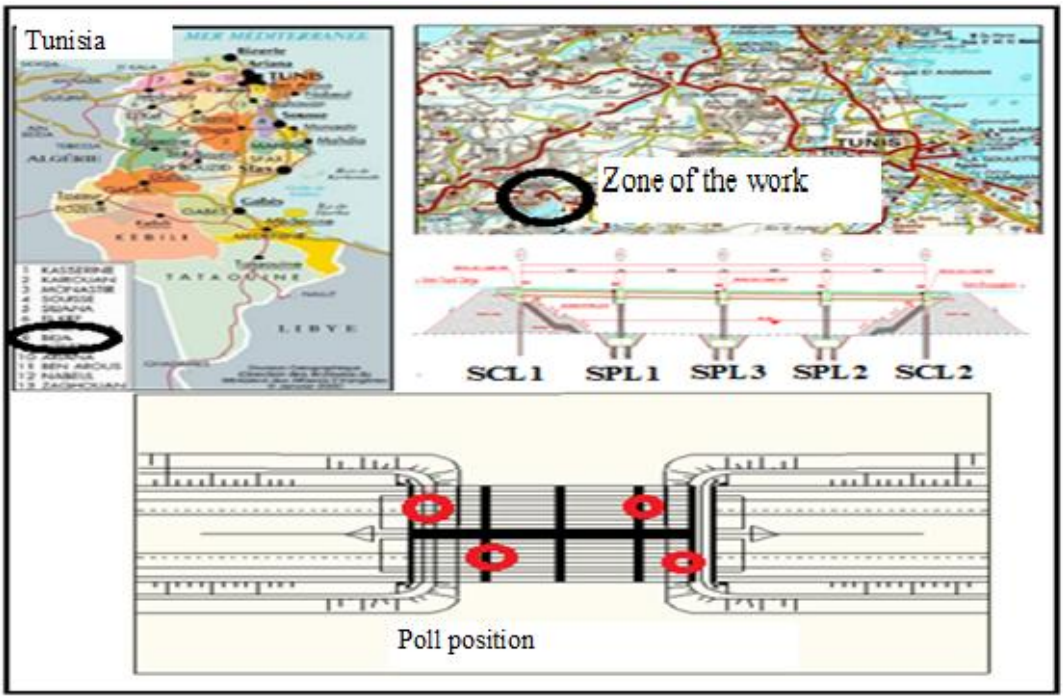

Figure I: Location of the study area

d) Lab Work

The laboratory work was carried out on the basis of the report of the geotechnical campaign and those at the Research Unityof Engineering, Industrial and Environmental Systems (URISIE) of the University Institute of Technology FOTSO Victor Bandjoun, associated with the Research Unityof Mechanics and of Physical Systems Modeling of the University of Dschang (UR2MSP).

e) Recognition of geological layers

The soil model is obtained thanks to the two cored holes and the two pressure tests. Using the geometric means of the pressure deformation moduli (Ep) and the limit pressures (Pl *) for each measuring point. Our study was based on the stack (P3) and on both abutments (C1; C2).

f) Allowable load of a pile

The bearing strength of a stake is the sum of two terms that are:

- Peak resistance (peak effect)
- The resistance due to lateral friction

For safety reasons, each of these terms is multiplied by a factor of safety to obtain the allowable load of the pile.

Calculation of the term of the peak effect

This resistance is a function of the area (section) of the pile, the equivalent net limit pressure (P * le) and the lift factor (Kp) which is a function of the conventional category of soils (type of land) and of the method execution of the pile. Hence the limit load of the pile is:

$$Qp = A * Ple * Kp \quad (1)$$

With

$$Ple = \left(\frac{1}{b+3a}\right)\int_{D-b}^{D+3a} Pl(z)dz \quad (2)$$

Moreover, this calculation is valid only in the case of a homogeneous carrier formation, that is to say a layer for which the maximum values of (P1) do not exceed twice the minimum values of (Pl).

Calculation of the term of lateral friction

The resistance due to lateral friction is a function of the perimeter, the thickness of the layers and the coefficient of lateral friction unit along the pile of the pile. It is defined by the following formula:

$$Qs = P * qs * \sum e \qquad (3)$$

With P: perimeter of the section of the pile
qs: unitary lateral friction
A: cross section area
e: thickness of the layer
Ple *: equivalent net limit pressure
b: min {a; h}; h being the height of the foundation element in the carrier layer
a: = {B / 2 if B> 1m; 0.5m if B <1m}
D: critical depth; it is a function of several factors such as:

- The type of soil
- Ground resistance
- The diameter of the pile and the ratio of De / B
- After various calculations and many other parameters, we will determine:

The limit load of a pile given by:

$$Ql = Qp + Qs \qquad (4)$$

The creep load of a pile given by:

$$Qc = \left(\frac{Qp}{2}\right) + \frac{Qs}{1.5} \qquad (5)$$

Verification of piles

After studies of the descent of load, we determined the loads applied on the piles which allowed us to carry out the checks to the different limit states and to different diameters such as:

- The Service Limit State is checked that:

$$Q < Qc/1.4 \qquad (6)$$

- The Ultimate Limit State is checked that:

$$Q < Ql/1.4 \qquad (7)$$

The checks below are carried out for piles of different diameters such as:

- ✓ 0.8 m
- ✓ 1 m
- ✓ 1.2 m

At each meter of depth and in this way, one manages to make the right choice concerning the depth and the diameter of the pile according to its location.

Transfer length

The transfer length (L0) determines the nature of the pile by its value. A pile will be long (or soft) if its length is greater than or equal to 3 * Lo.

$$Lo = \sqrt[4]{\frac{4*Ep*Ip}{Es}} \qquad (8)$$

With:

- Ep: concrete module
- Ip: inertia of the pile
- Es: soil module

Es is the soil module (not determine the Ménard formula)

4. Results

At the end of this study, it emerges: "the determination of the typical profile of the terrain and the loads acting on the piles": the different values of the average limit pressures, the average pressure modules and the typical profile of the terrain. In addition, the critical embedment depth of the foundations, the stresses and deformations in the piles which are presented in the following tables and figures:

Determination of the different layers of soil

	SP1 survey							
	Prof (m)	PL (MPa)	Po (MPa)	PL* (MPa)	PL* moyen	Ep (MPa)	Ep moyen	Plmoyen
Clay	1	2,6	0,09	2,51	2,7745395	17	19,0680839	3,0801516
	2	3,3	0,18	3,12		22		
	3	2,6	0,27	2,33		15		
	4	2,9	0,36	2,54		18		
	5	3	0,45	2,55		17		
	6	4,4	0,54	3,86		28		
Sand	7	10,5	0,63	9,87	14,025168	79	111,852443	15,009375
	8	12,6	0,72	11,88		94		
	9	16,1	0,81	15,29		111		
	10	17,4	0,9	16,5		140		
	11	17,9	0,99	16,91		146		
	12	16,2	1,08	15,12		115		
	13	12,9	1,17	11,73		88		
	14	14,3	1,26	13,04		98		
	15	19,5	1,35	18,15		164		
Shingle	16	79,6	1,44	78,16	77,2454	2370	2335,22181	78,867473
	17	79,7	1,53	78,17		2403		
	18	79,4	1,62	77,78		2303		
	19	79,6	1,71	77,89		2348		
	20	76,1	1,8	74,3		2255		
Sand	21	15,2	1,89	13,31	14,242038	96	101,315448	16,265258
	22	15,3	1,98	13,32		96		
	23	17,1	2,07	15,03		103		
	24	17,6	2,16	15,44		111		
Shingle	25	36,8	2,25	34,55	37,766891	514	622,711658	40,339467
	26	63,5	2,34	61,16		1219		
	27	49,3	2,43	46,87		940		
	28	34,5	2,52	31,98		486		
	29	30,8	2,61	28,19		420		
	30	35,2	2,7	32,5		485		
Clay	31	14,3	2,79	11,51	10,727523	70	67,3796114	13,701018
	32	12,8	2,88	9,92		61		
	33	13,4	2,97	10,43		64		
	34	13,3	3,06	10,24		66		
	35	14,8	3,15	11,65		77		

Figure 2: Determination of the different soil layers on pile N ° 1

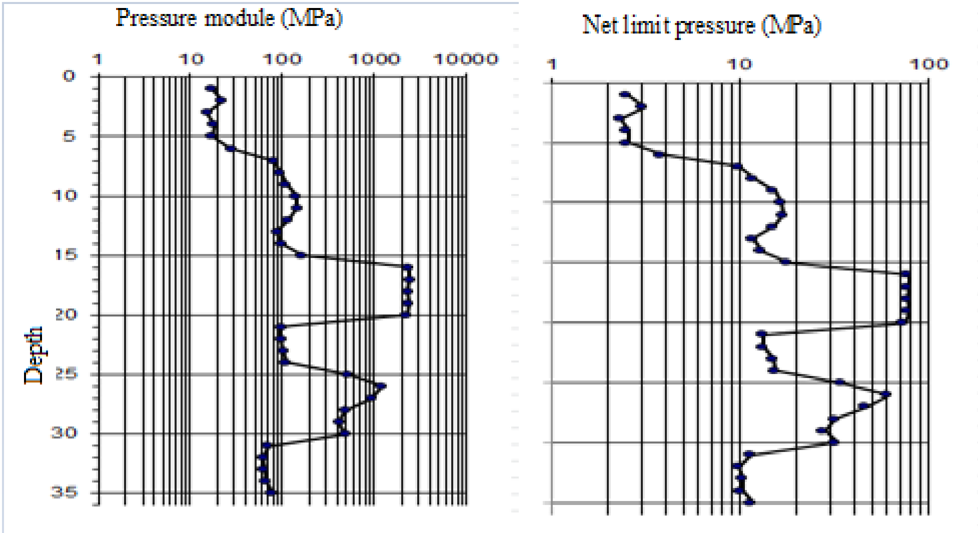

Figure 3: Different profiles of the pressures on the battery N ° 1

	SP3 survey							
	Prof (m)	PL (MPa)	Po (MPa)	PL* (MPa)	PL* moyen	Ep (MPa)	Ep moyen	Plmoyen
	1	6,9	0,09	6,81		78		
	2	9,8	0,18	9,62		112		
	3	11,5	0,29	11,21		128		
	4	10,6	0,43	10,17		117		
	5	10,5	0,58	9,92		114		
	6	10,5	0,72	9,78		112		
Clay	7	11,1	0,87	10,23	11,309483	119	138,455605	12,167607
	8	11,9	1,01	10,89		125		
	9	14,3	1,16	13,14		151		
	10	11,8	1,3	10,5		122		
	11	11,4	1,45	9,95		115		
	12	15,6	1,59	14,01		196		
	13	18,9	1,74	17,16		272		
	14	22,9	1,88	21,02		339		
	15	76,1	2,03	74,07		3042		
	16	76	2,17	73,83		2967		
Shingle	17	76,2	2,32	73,88	68,778277	2990	2785,81301	71,204757
	18	51	2,46	48,54		1959		
	19	76,5	2,61	73,89		2962		
	20	75,8	2,75	73,05		2985		
	21	10	2,9	7,1		82		
Clay	22	12,8	3,04	9,76	10,199083	110	130,430917	13,328887
	23	18,5	3,19	15,31		246		
	24	35,1	3,33	31,77		695		
Sand	25	35,1	3,48	31,62	31,078012	700	684,07373	34,558351
	26	33,5	3,62	29,88		658		
	27	76,2	3,77	72,43		2920		
	28	76,5	3,91	72,59		2905		
	29	77,1	4,06	73,04	70,590459	2973	2665,37529	74,7336
	30	77	4,2	72,8		2929		
Shingle	31	73,6	4,35	69,25		2464		
	32	68,4	4,49	63,91		1970		
	33	17,5	4,64	12,86		213		
	34	12,6	4,78	7,82	8,9671746	127	145,980122	13,869623
Clay	35	12,1	4,93	7,17		115		

Figure 4: Determination of the different soil layers on the pile N ° 3

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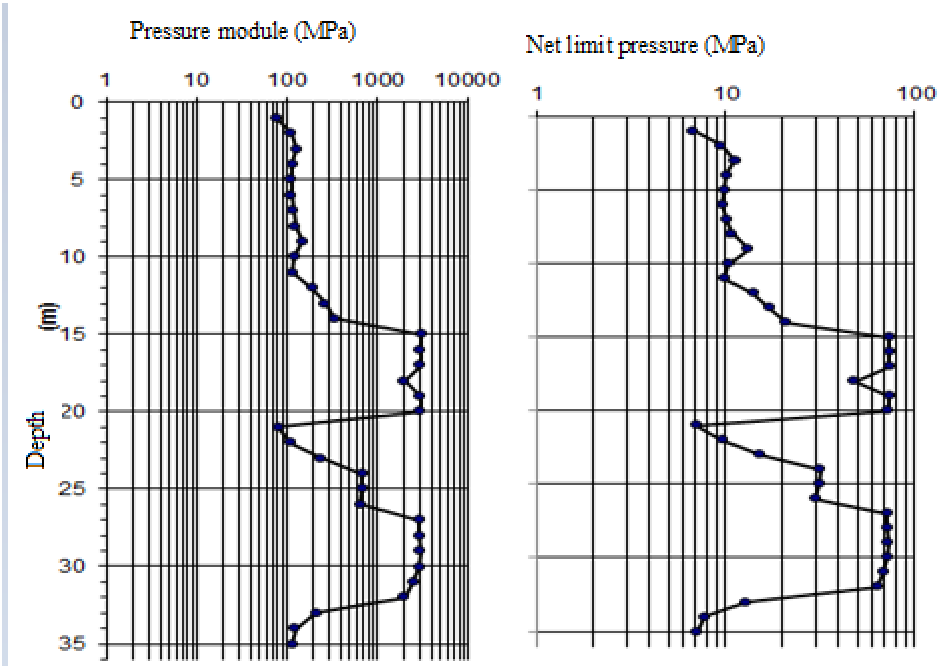

Figure 5: Different profiles of the pressures on the stack N ° 3

• Determination of the soil type profile

Typical profile of the land			
Type of soil	N°	PL* (MPa)	Epmoyen (MPa)
Brownish siliceous clay	1	5,602	51,382
Fine sand brownish bank	2	31,058	558,211
Siliceous sandblaster	3	28,068	551,892
Sand silico clay bank	4	21,038	263,263
Clay-sandy matrix	5	51,633	1288,317
Gritty siliceous clay	6	9,808	99,177

Figure 6: Synthesis of the different soil layers resulting from the cored holes and the pressures

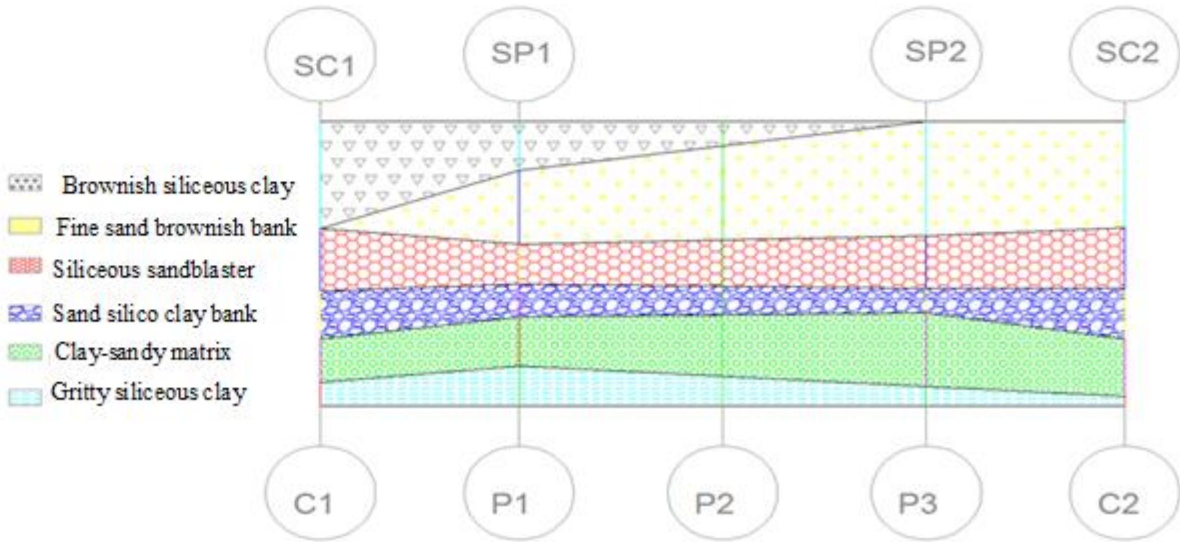

Figure 7: Profile Type of Soil

• Determination of the embedment depth of a pile

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Permissible load of a pile vis-à-vis the material			(ELS)
Diameter D (m)	0,8	1	1,2
Area A(m²)	0,5024	0,785	1,1304
Perimeter P(m)	2,512	3,14	3,768
Characteristic resistance of concrete	(Mpa)		6
Q adm (kN)	3014,4	4710	6782,4

Figure 8: Determination of the allowable load of a pile

Permissible load of a pile to the ground								Number of piles per file				Verification of the material
Inking layer	L	Qp	Qs	QL	Qc	Q adm (kN)		1 file		2 files		
	(m)	(KN)	(KN)	(KN)	(KN)	ELU	ELS	ELU	ELS	ELU	ELS	
	1											
1	2											
	3											
	4											
	5											
	6	1087,5213	125,600	1213,121	631,68063	866,51519	451,20045	Non	Non	Non	Non	Ok
	7	1087,5213	251,200	1338,721	719,60063	956,22948	514,00045	Non	Non	Non	Non	Ok
	8	1087,5213	376,800	1464,321	807,52063	1045,9438	576,80045	Non	Non	Non	Non	Ok
	9	1087,5213	502,400	1589,921	895,44063	1135,658	639,60045	Non	Non	Non	Non	Ok
2	10	1087,5213	628,000	1715,521	983,36063	1225,3723	702,40045	Non	Non	Non	Non	Ok
	11	1087,5213	753,600	1841,121	1071,2806	1315,0866	765,20045	Non	Non	Non	Non	Ok
	12	1087,5213	879,200	1966,721	1159,2006	1404,8009	828,00045	Non	Non	Non	Non	Ok
	13	1087,5213	1004,800	2092,321	1247,1206	1494,5152	890,80045	Non	Non	Non	Non	Ok
	14	1087,5213	1130,400	2217,921	1335,0406	1584,2295	953,60045	Non	Non	Non	Non	Ok
	15	1087,5213	1256,000	2343,521	1422,9606	1673,9438	1016,4005	Non	Non	Non	Non	Ok
	16	10223,157	1256,000	11479,157	5990,7783	8199,3976	4279,1274	ok	ok	Ok	Ok	Ok
	17	10223,157	1256,000	11479,157	5990,7783	8199,3976	4279,1274	ok	ok	Ok	Ok	Ok
3	18	10223,157	1256,000	11479,157	5990,7783	8199,3976	4279,1274	ok	ok	Ok	Ok	Ok
	19	10223,157	1256,000	11479,157	5990,7783	8199,3976	4279,1274	ok	ok	Ok	Ok	Ok
	20	10223,157	1256,000	11479,157	5990,7783	8199,3976	4279,1274	ok	ok	Ok	Ok	Ok
	21	1135,318	1381,600	2516,918	1534,779	1797,7986	1096,2707	Non	Non	Non	Non	Ok
4	22	1135,318	1507,200	2642,518	1622,699	1887,5129	1159,0707	Non	Non	Non	Non	Ok
	23	1135,318	1632,800	2768,118	1710,619	1977,2272	1221,8707	Non	Non	Non	Non	Ok
	24	1135,318	1758,400	2893,718	1798,539	2066,9414	1284,6707	Non	Non	Non	Non	Ok
	25	6159,9754	1758,400	7918,375	4310,8677	5655,9825	3079,1912	ok	ok	Ok	Ok	Ok
	26	6159,9754	1758,400	7918,375	4310,8677	5655,9825	3079,1912	ok	ok	Ok	Ok	Ok
	27	6159,9754	1758,400	7918,375	4310,8677	5655,9825	3079,1912	ok	ok	Ok	Ok	Ok
5	28	6159,9754	1758,400	7918,375	4310,8677	5655,9825	3079,1912	ok	ok	Ok	Ok	Ok
	29	6159,9754	1758,400	7918,375	4310,8677	5655,9825	3079,1912	ok	ok	Ok	Ok	Ok
	30	6159,9754	1758,400	7918,375	4310,8677	5655,9825	3079,1912	ok	ok	Ok	Ok	Ok
	31	6159,9754	1758,400	7918,375	4310,8677	5655,9825	3079,1912	ok	ok	Ok	Ok	Ok
	32	923,90738	1877,720	2801,627	1776,3577	2001,1624	1268,8269	Non	Non	Non	Non	Ok
6	33	923,90738	1997,040	2920,947	1859,8817	2086,391	1328,4869	Non	Non	Non	Non	Ok
	34	923,90738	2116,360	3040,267	1943,4057	2171,6196	1388,1469	Non	Non	Non	Non	Ok
	35	923,90738	2235,680	3159,587	2026,9297	2256,8481	1447,8069	Non	Non	Non	Non	Ok

Figure 9: Choice of the embedding layer and determination of the embedment depth of the pile

Determination of the solicitations in the pile

General data					
Stake			Ground		
Elasticity module	E (kN/m²)	32164195	Feedback module	k (kN/m³)	207156,175
Length	L (m)	21	Efforts applied at the top		
Diameter	B (m)	1	Horizontal effort	H (kN)	77,4
Inertia	I (m⁴)	0,04908734	Bending moment	M (kN.m)	0,00

Calculation parameters				
Transfer length	Lo	2,34977393	(m)	
Maximum depth	x_{max}	8,93702995	(m)	
Increment	Δx	0,4468515	(m)	
Calculation condition	21	>	7,0493218	Ok

Figure 10: Determination of the Transfer Length of a Pile

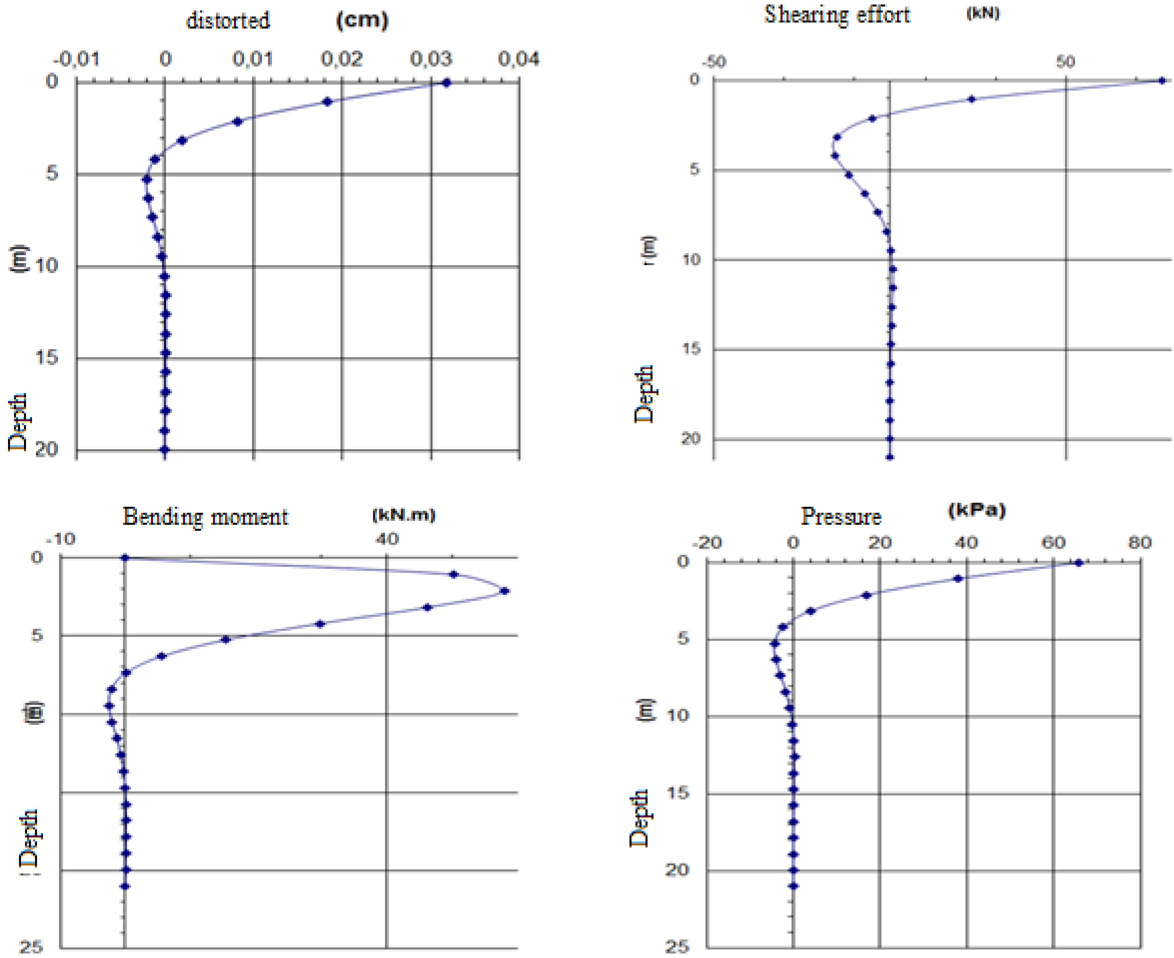

Figure 11: Different Curves of the Solicitations acting in a pile

5. Discussion

After performing the various calculations according to the Norms, SETRA documents and DTU (Unified Technical Documents), it follows:

- At the foundation of the abutment, we took two rows like that of the pile because the pile at this level is very busy due to the fact that the bed of the watercourse is practically flat. And therefore, we do not have complete confidence in the embankment at the abutment.
- We note that the foundations can be embedded in the 3rd or 5th layer of soil, which is a function of the permissible load and the number of piles per wire.
- The choice of the soil layer in which we must anchor our foundation is determined by determining the height of each layer plus three times the diameter of the pile and must be checked with respect to the transfer length of the pile.

6. Conclusion and Perspectives

6.1 Conclusion

In this project, we are interested in the determination of the typical soil profile on which we must base our crossing work on OuedZarga-Rhayette located on Highway A3 in the Bousalem area. During this project we tried to carry out a general and complete study of a structure of art and for that we had the obligation to follow and to study closely every step of design and dimensioning of the bridge to beam. From this comes the following: the determination of the typical soil profile, the characteristics of the different soil layers and the stresses acting on the piles. The calculations of the various elements of our work are carried out with reference to the recommendations of SETRA and based on the rules of the BAEL 91. Finally, the results obtained during this study set the milestones for the determination of the standard profiles. Soils and stresses acting on piles in order to dimension the deep foundations of the Works of Art.

6.2 Prospects

- Determination of the reinforcement of the piles
- Dimensioning of the connecting flange
- Use of Eurocode 2 for the calculation of Reinforced Concrete

Implication of the Model to Research And Practice

The creation of the EXEL micro-programs for the determination of the typical soil profile, the characteristics of the soil layers and the stresses acting on piles.

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