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DEVELOPMENT OF A DYNAMIC PENETROMETER PREDICTION MODEL CONSIDERING THE PHYSICAL PROPERTIES OF THE INFRASTRUCTURE GROUND

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ABSTRACT

The article presents a model, obtained from the heavy dynamic penetrometer test and physical parameters. It has been established that there are correlations between resistance to dynamic penetrometer, natural water content and void index. On the basis of the established correlations, a model for the determination of resistance to dynamic penetrometer in relation to these simple and less costly physical parameters has been developed. Following the verification of its validity, the developed model is proposed for the sizing of the foundations of the civil engineering works of the city of Amtiman and its surroundings. This model contributes to the reduction of geotechnical testing costs.

KEYWORDS: Model, heavy dynamic penetrometer, correlations, physical parameters, Amtiman, foundation.

1. INTRODUCTION

Determining the mechanical properties of the floors for the design of the various structures is one of the most difficult tasks in foundation engineering. In Chad, these difficulties are linked to the costs of geotechnical tests, which are very high and are not always accessible to the majority of the population. In view of all the above, the development of a model which could facilitate the determination of the mechanical parameters of the soils to be used in the study of construction projects is of great importance and topical. It is important to note that soils are not homogeneous materials [1, 2]. Their properties depend on several factors such as the nature of the parent rocks from which they are derived, the climatic conditions under which they were formed, the degree of physical disintegration and chemical alteration of their particles, their porous nature, their chemical and mineralogical composition etc [3-5]. Two soils similar to the naked eye can have different properties and hence different behaviours under loads. To date, no work has been done to model the soil characteristics of Chad. This article proposes a model for determining the resistance to the dynamic penetrometer of the soils of the city of Amtiman (Figure1) from the physical characteristics (water content and void index) simple and less costly.

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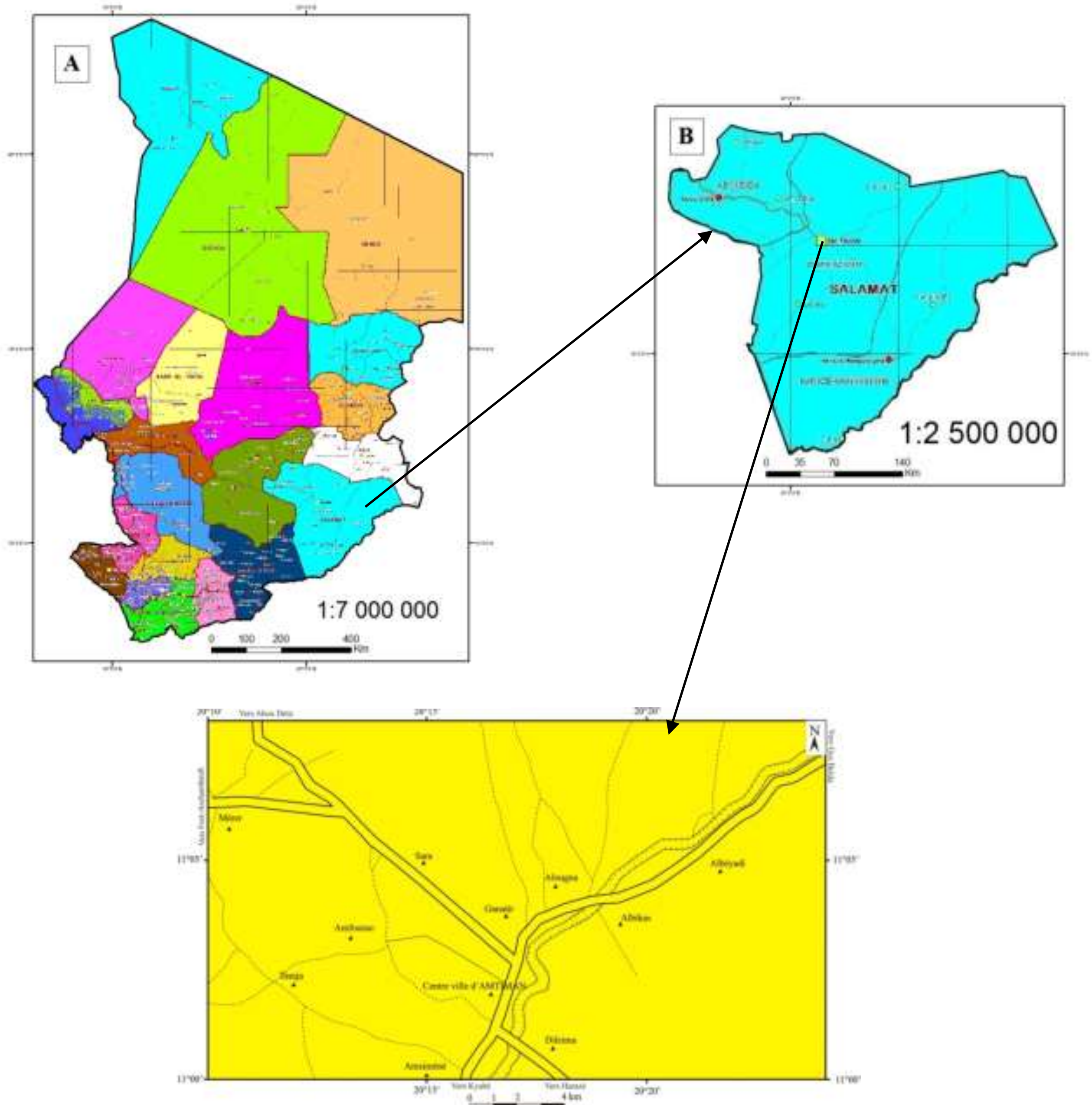

Figure 1: Study Area Location Map (6)

A: Map of Chad *B: Map of Salamat* *C: Study area*

2. METHODOLOGY

2.1 Location of Penetrometric Sampling Points and Sampling Points

The sites selected were located in different parts of the city and exhibiting all the apparent differences in soil color. The sampling was done by core sampling and the intact and redesigned samples were taken.

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2.2. Experimentation

2. 2.1. Determination of soil physical characteristics

The physical characteristics determined are the particle size composition according to the requirements of standard NF P 94 – 056, the limits of Atterberg according to standard NF P 94-051, the natural water content according to the requirements of NF P 94 – 050, the density of solid grains according to NF P 94 – 054 and the apparent density by the method of the cutting kit [7-10]. The plasticity index, the degree of saturation, the density of the dry soil, the void index and the porosity were calculated using the relationships between the different physical characteristics of the soils.

2. 2.2. Determination of resistance to dynamic penetrometer

It was determined on thirteen (13) sampling points using the heavy dynamic penetrometer, in accordance with the requirements of NF P 94 115 [11].

The dynamic penetration test consists of thrusting metal rods preceded by a point into the ground. It's a geotechnical reconnaissance tool to know the strength of the ground in place. It consists in determining the number of blows required to drive, according to a defined procedure, a spike subjected, through a train of rods, to a threshing energy. This test makes it possible to assess in a qualitative way the resistance of the terrains crossed in order to guide the choice of foundations. From this number of hits, one can appreciate:

• The succession of different layers of terrain;
• The homogeneity of a layer or the presence of anomalies;
• The position of a resistant layer known to exist.

2.3. Statistical treatment of test results, correlation of physical-mechanical characteristics and model development

Statistical analysis was carried out by SPSS 2.0 to determine arithmetic averages, maximum values, minimum values, coefficients of variation and standard deviations. The development of the dynamic strength model began with the study of the correlations between this characteristic and all the physical characteristics of the soils. For this purpose, in order to assess the degree of influence of each physical characteristic on resistance to dynamic penetrometer, an analysis of the different dependency relationships was performed using the two-order polynomial regression functions using the graphical option of the 2007 Excel spreadsheet.

$$Y = a + bX + cX^2 \quad (1)$$

Where X and Y are respectively the physical characteristic considered and the resistance to the dynamic penetrometer; a, b and c are the coefficients of the function (1), determined using the least squares method. The values of the correlation coefficients R obtained made it possible to assess the degree of dependence between dynamic resistance and physical characteristics using the following scale [12]:

- $R < 0.50$: Low correlation
- $0.50 \leq R \leq 0.70$: Average correlation
- $0.70 \leq R \leq 0.90$: Good correlation
- $0.90 \leq R \leq 1$: Strong correlation.

• Choose the regression equation:

$$Y = a_0 + a_1 X_1 + a_2 X_2 + a_3 X_1X_2 + a_4 X_1^2 + a_5 X_2^2 \quad (2)$$

Where Y is the mechanical parameter and X_1, X_2 are considered physical parameters;

• Determine regression parameters ;
• Establish the model.

3. RESULTS AND DISCUSSION

3.1. Physical and mechanical characteristics

The study of the physical characteristics of the soils of the town of Amtiman was carried out on 69 samples. The results of these physical and mechanical parameters are presented in Tables 1 and 2.

Table 1: Physical characteristics of the soils of the town of Amtiman [13]

Statistical indices	ω (%)	S_r (%)	ω_L (%)	ω_p (%)	I_P (%)	ρ_s (g/cm^3)	ρ (g/cm^3)	ρ_d (g/cm^3)	e	n (%)	particles < 0,080mm (%)
Minimum value X_{min}	10,00	10,43	37,70	18,30	13,6	2,00	1,00	0,87	0,54	35,06	34,70
Maximum value X_{max}	29,00	45,64	82,60	41,30	44,0	2,73	1,59	1,56	1,88	65,27	98,20
Average value X_{moy}	17,35	28,07	59,95	31,44	28,5	2,47	1,22	1,07	1,31	55,96	76,66

The data in Table 1 show that the soils studied have a fine character and a high average plasticity.

Table 2: Dynamic soil resistance in the town of Amtiman

Statistical indices	The dynamic Resistance R_{Pdyn} (bars)
Minimum value X_{min}	10,17
Maximum value X_{max}	87,26
Average value X_{moy}	43,93
Standard deviation	21,87
Coefficient of variation (%)	49,78

Table 2 shows that, overall, the resistance to dynamic penetrometer of the soils studied varies considerably between 10.17 and 87.26 bars, with an average value of 43.93 bars, a standard deviation of 21,87 bars and a coefficient of variation of 49.78%.

3.2. Correlations between dynamic resistance and physical parameters

The study of the relationships between dynamic resistance R_{Pdyn} and physical parameters was carried out using the point cloud method. The correlation coefficients obtained are shown in Table 3 in which ω_p, ω_L, I_P, I_c, I_L, ρ, ρ_s, ρ_d, ω, n, e, S_r and $d_{0,08}$ are respectively the plasticity limit, the liquidity limit, the plasticity index, consistency index, liquidity index, density, density of solid grains, dry density, natural water content, porosity, void index, the degree of saturation and the percentage of particles below 0.080 mm.

Table 3: Correlations between Dynamic Resistance R_{Pdyn} and the Physical Characteristics of Amtiman City Soils

Physical characteristics	ω_p	ω_L	I_P	I_c	I_L	ρ	ρ_s	ρ_d	ω	n	e	S_r	$d_{0,08}$
R correlation coefficient between R_{Pdyn} and X	0,13	0,08	0,03	0,10	0,08	0,25	0,36	0,58	0,70	0,81	0,81	0,30	0,27

Table 3 shows that the physical parameters having a considerable influence on the dynamic strength of the soils studied are the dry density, water content, porosity and void index. The correlations between dynamic resistance and water content, dry density, porosity and void index are average to good, with correlation coefficients of 0.70; 0.58; 0.81 and 0.81 respectively. The degree of bond between ω_p, ω_L, I_P, I_c, I_L, ρ, ρ_s, S_r and $d_{0,08}$ is low, with correlation coefficients of 0.13; 0.08; 0.03; 0.1; 0.08; 0.25; 0.36; 0.30 and 0.27. These low values show that these latter physical parameters have little influence on the cohesion of the soils studied. The relationships between water content, dry density, porosity and void index are given by the following mathematical expressions:

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$R_{Pdyn} = 0{,}143\ \omega^2\ - 8{,}145\omega + 134{,}3$
$R_{Pdyn} = -\ 25{,}82\ \rho^2{}_d\ + 151{,}6\ \rho_d\ -\ 90{,}99$
$R_{Pdyn} = 0{,}244\ n^2 - 31{,}23n + 1022$
$R_{Pdyn} = 90{,}68\ e^2 - 309{,}8e + 288{,}7$
$R_{Pdyn} = f(w); f(\rho_d);\ f(n); f(e).$

Normally, a model for the determination of R_{Pdyn} should be made taking into account all four (4) physical characteristics: water content (ω), dry density ρ_d, porosity (n) and void index (e). However,ρ_d n and e are all three parameters of density. Therefore, we must take into account only one of these last three. Since the correlation coefficient of the void index (e) is equal to that of the porosity index (n), the void index is therefore finally retained. From the above, the resistance to the dynamic penetrometer of the soils of the city of Amtiman and its surroundings as a function of the water content and the void index is expressed as follows:

$R_{Pdyn} = f(\omega, e)$ (3)

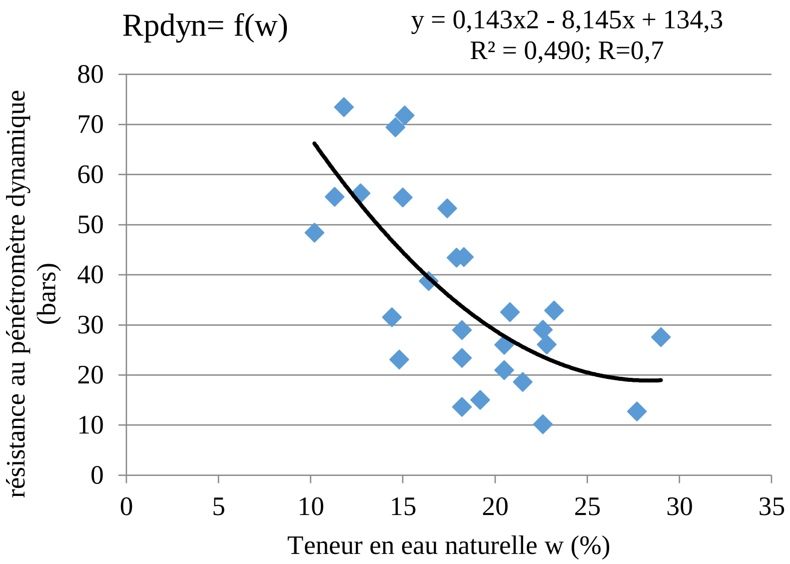

Figure 2: Correlation between dynamic resistance and natural water content

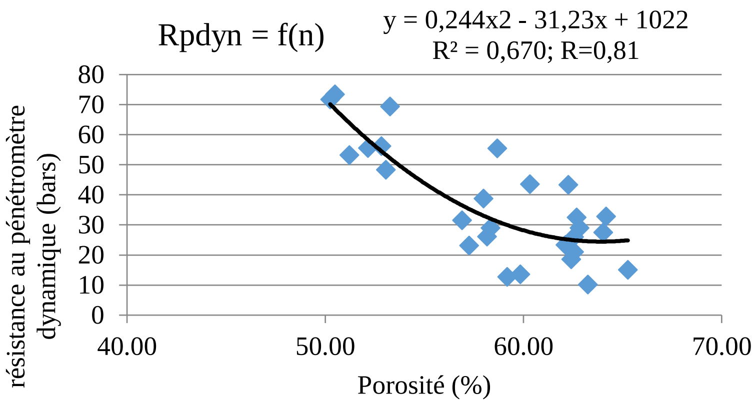

Figure 3: Correlation between dynamic resistance and porosity

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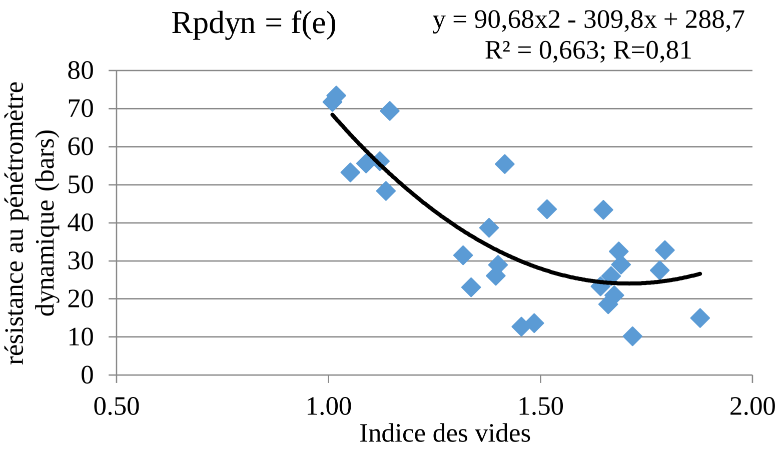

Figure 4: Correlation between dynamic resistance and void index

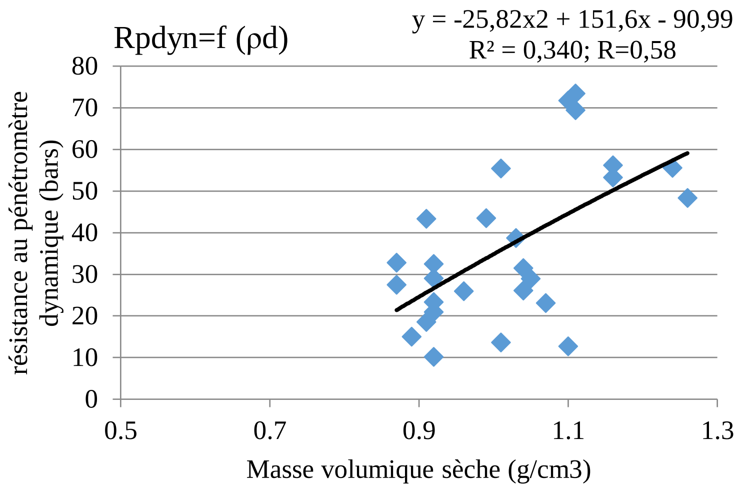

Figure 5: Correlation between dynamic resistance and dry density

3.3. Determination of regression parameters

Since the number of physical parameters most important for the mechanical characteristic is equal to two, the non-linear regression function is expressed as:

$$Y = a_0 + a_1 w + a_2 e + a_3 \, we + a_4 \, w^2 + a_5 \, e^2 \qquad (4)$$

where Y is the considered mechanical parameter; ω and e are the two physical parameters taken into account; a_0 a_1, a_2, a_3, a_4 and a_5 are the coefficients of the function , obtained by solving the system of six six unknown equations composed as follows, using the least square method. Thus, the equation system is as follows:

$$\begin{cases} na_0 + a_1\sum_{i=1}^{n}\omega_i + a_2\sum_{i=1}^{n}e_i + a_3\sum_{i=1}^{n}\omega_i\, e_i + a_4\sum_{i=1}^{n}\omega_i^2 + a_5\sum_{i=1}^{n}e_i^2 = \sum_{i=1}^{n}Y_i \\ a_0\sum_{i=1}^{n}\omega_i + a_1\sum_{i=1}^{n}\omega_i^2 + a_2\sum_{i=1}^{n}\omega_i^2 e_i^2 + a_3\sum_{i=1}^{n}\omega_i^2 e_i + a_4\sum_{i=1}^{n}\omega_i^3 + a_5\sum_{i=1}^{n}\omega_i\, e_i^2 = \sum_{i=1}^{n}\omega_i Y_i \\ a_0\sum_{i=1}^{n}e_i + a_1\sum_{i=1}^{n}\omega_i\, e_i + a_2\sum_{i=1}^{n}e_i^2 + a_3\sum_{i=1}^{n}\omega_i {e^2}_i + a_4\sum_{i=1}^{n}\omega_i^2\, e_i + a_5\sum_{i=1}^{n}e_i^3 = \sum_{i=1}^{n}e_i Y_i \\ a_0\sum_{i=1}^{n}\omega_i e_i + a_1\sum_{i=1}^{n}\omega_i^2\, e_i + a_2\sum_{i=1}^{n}\omega_i {e_i^2}_i + a_3\sum_{i=1}^{n}\omega_i^2 e_i^2 + a_4\sum_{i=1}^{n}\omega_i^3\, e_i + a_5\sum_{i=1}^{n}\omega_i e_i^3 = \sum_{i=1}^{n}\omega_i e_i Y_i \\ a_0\sum_{i=1}^{n}\omega_i^2 + a_1\sum_{i=1}^{n}\omega_i^3 + a_2\sum_{i=1}^{n}\omega_i^2\, e_i + a_3\sum_{i=1}^{n}\omega_i^3 e_i + a_4\sum_{i=1}^{n}\omega_i^4 + a_5\sum_{i=1}^{n}\omega_i^2 e_i^3 = \sum_{i=1}^{n}\omega_i^2 Y_i \\ a_0\sum_{i=1}^{n}e_i^2 + a_1\sum_{i=1}^{n}\omega_i\, e_i^2 + a_2\sum_{i=1}^{n}e_i^3 + a_3\sum_{i=1}^{n}\omega_i e_i^3 + a_4\sum_{i=1}^{n}\omega_i^2\, e_i^2 + a_5\sum_{i=1}^{n}e_i^4 = \sum_{i=1}^{n}e_i^2 Y_i \end{cases}$$

Thus the system was written in the following matrix form:

$$A = \begin{pmatrix} n & \sum_{i=1}^{n}\omega_i & \sum_{i=1}^{n}e_i & \sum_{i=1}^{n}\omega_i\, e_i & \sum_{i=1}^{n}\omega_i^2 & \sum_{i=1}^{n}e_i^2 \\ \sum_{i=1}^{n}\omega_i & \sum_{i=1}^{n}\omega_i^2 & \sum_{i=1}^{n}\omega_i^2 e_i^2 & \sum_{i=1}^{n}\omega_i^2 e_i & \sum_{i=1}^{n}\omega_i^3 & \sum_{i=1}^{n}\omega_i\, e_i^2 \\ \sum_{i=1}^{n}e_i & \sum_{i=1}^{n}\omega_i\, e_i & \sum_{i=1}^{n}e_i^2 & \sum_{i=1}^{n}\omega_i {e^2}_i & \sum_{i=1}^{n}\omega_i^2\ e_i & \sum_{i=1}^{n}e_i^3 \\ \sum_{i=1}^{n}\omega_i e_i & \sum_{i=1}^{n}\omega_i^2\, e_i & \sum_{i=1}^{n}\omega_i {e_i^2}_i & \sum_{i=1}^{n}\omega_i^2 e_i^2 & \sum_{i=1}^{n}\omega_i^3\, e_i & \sum_{i=1}^{n}\omega_i e_i^3 \\ \sum_{i=1}^{n}\omega_i^2 & \sum_{i=1}^{n}\omega_i^3 & \sum_{i=1}^{n}\omega_i^2\, e_i & \sum_{i=1}^{n}\omega_i^3 e_i & \sum_{i=1}^{n}\omega_i^4 & \sum_{i=1}^{n}\omega_i^2 e_i^3 \\ \sum_{i=1}^{n}e_i^2 & \sum_{i=1}^{n}\omega_i\, e_i^2 & \sum_{i=1}^{n}e_i^3 & \sum_{i=1}^{n}\omega_i e_i^3 & \sum_{i=1}^{n}\omega_i^2\, e_i^2 & \sum_{i=1}^{n}e_i^4 \end{pmatrix}. \ X = \begin{pmatrix} a_0 \\ a_1 \\ a_2 \\ a_3 \\ a_4 \\ a_5 \end{pmatrix} =$$

$$B = \begin{pmatrix} \sum_{i=1}^{n}Y_i \\ \sum_{i=1}^{n}\omega_i Y_i \\ \sum_{i=1}^{n}e_i Y_i \\ \sum_{i=1}^{n}\omega_i e_i Y_i \\ \sum_{i=1}^{n}\omega_i^2 Y_i \\ \sum_{i=1}^{n}e_i^2 Y_i \end{pmatrix}$$

Solve the system in $AX = B$

The resolution of the system using the Matlab R 2013a software consisted in finding the X matrix by multiplying the inverse of the A matrix by the B matrix $[X = (inv.of\ A) * B]$ [14]. Obtaining the matrix X, the components of which are the coefficients a_0 a_1,a_2,a_3, a_4 and a_5 allowed Y to be expressed as equation (4).

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$$Matrix\ A = \begin{bmatrix} 2.700000000000000e+01 & 4.949000000000000e+02 & 3.910000000000000e+01 \\ 4.949000000000000e+02 & 9.637489999999998e+03 & 7.401080000000000e+02 \\ 3.910000000000000e+01 & 7.401080000000000e+02 & 5.845519999999999e+01 \\ 7.401080000000000e+02 & 1.479484520000000e+04 & 1.137478140000000e+03 \\ 9.637489999999998e+03 & 1.982961110000000e+05 & 1.479484520000000e+0 \\ 5.845519999999999e+01 & 1.137478140000000e+03 & 8.983790800000000e+01 \\ 7.401080000000000e+02 & 9.637489999999998e+03 & 5.845519999999999e+01 \\ 1.479484520000000e+04 & 1.982961110000000e+05 & 1.137478140000000e+0 \\ 1.137478140000000e+03 & 1.479484520000000e+04 & 8.983790800000000e+01 \\ 2.323570269000000e+04 & 3.106682452400000e+05 & 1.788809837000000e+03 \\ 3.106682452400000e+05 & 4.287205957700000e+06 & 2.323570269000000e+04 \\ 1.788809837000000e+03 & 2.323570269000000e+04 & 1.413253218800000e+02 \end{bmatrix}$$

Matrix B: Second member

$$B = \begin{bmatrix} 9.810199999999999e+02 & 1.647976100000000e+04 & 1.323301200000000e+03 \\ 2.313300514000000e+04 & 2.955751069000001e+05 & 1.856740954000000e+03 \end{bmatrix}$$

Matrix C, opposite of the Matrix A

$$C = \begin{bmatrix} +4.276112337085711e+01 & -4.096435961409267e-01 & -5.652599315615457e+01 \\ -4.096435961409267e-01 & +1.447322125854328e-01 & -1.206960513990783e+00 \\ -5.652599315615457e+01 & -1.206960513990783e+00 & +9.719844298703454e+01 \\ +2.895416579415902e-01 & -7.703342496703133e-02 & +5.988616455259619e-01 \\ +1.250476182923666e-04 & -6.772082243028945e-04 & +6.078595997231447e-03 \\ +1.785728856587602e+01 & +8.581649324515963e-01 & -3.727191507491548e+01 \\ +2.895416579415902e-01 & +1.250476182923666e-04 & +1.785728856587602e+01 \\ -7.703342496703133e-02 & -6.772082243028945e-04 & +8.581649324515963e-01 \\ +5.988616455259619e-01 & +6.078595997231447e-03 & -3.727191507491548e+01 \\ +2.016614888669352e-01 & -5.340663076535179e-03 & -1.554865389173799e+00 \\ -5.340663076535179e-03 & +2.076316268762057e-04 & +3.499638529282249e-02 \\ -1.554865389173799e+00 & +3.499638529282249e-02 & +2.333360014566995e+01 \end{bmatrix}$$

$$X = \begin{bmatrix} 2.890627471733387e+02 & -2.679118430172366e+00 & -2.748743380026572e+02 \\ 6.515011663184851e+00 & -1.893663673915995e-01 & 3.854254834516905e+01 \end{bmatrix}$$

The R_{Pdyn} determination model developed is therefore as follows:

$$R_{Pdyn} = 289{,}063 - 2{,}679w - 274{,}87e + 6{,}515we - 0{,}189w^2 + 38{,}542e^2 \quad (5)$$

3.4. Validation of the model

We checked the model by comparing the dimensions of the soles determined with the use of the permissible stress values (σ_{adm}) obtained using the model with those obtained using the experimental permissible stress values. For this purpose, for the sizing we used the Dutch method described as follows (15-17):

$$Q_d = \frac{Mgh}{Ae} \cdot \frac{M}{M+m} \quad (6)$$

The permissible stress is obtained by dividing the dynamic resistance by 20. This value consists of an overall safety coefficient of 3 and a reduction coefficient of 6.6. The latter makes it possible to take into account the vagaries of the experimentation of the method with the dynamic penetrometer and the transition from the dynamic loading mode to the static loading mode which actually corresponds to that of the loads that the structures transmit to the carrier ground.

Example on a case

Determination of the dimensions of an insulated sole under a section post $a = 15\ cm$ and $b = 20\ cm$, knowing that the permissible stress of the soil $\sigma_{adm} = 2.81$ bars and that determined by the model is $\sigma_{adm} = 2.88$ bars. The service load transmitted to the foundation is P_{ser}.= 980 kN The density of the concrete is 25 kN/m^3.The condition to prevent ground failure while maintaining a coefficient of safety is that the stress (pressure) exerted on the ground by the sole is less than or equal to the permissible stress of the ground.

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$\frac{P_{ser}}{AB} \leq \sigma_{adm}$ (7)

That is $AB \geq \frac{Pser}{\sigma_{adm}}$ (8)

The dimensions of the sole and the post must be homothetic, that is to say:
$\frac{A}{B} = \frac{a}{b}$ Give $A = \frac{a}{b} xB$ (9)

(9) In (8) Give $\frac{a}{b} B^2 \geq \frac{P_{ser}}{\rho_{adm}}$ Consequently $B = \sqrt{\frac{P_{ser} b}{\rho_{adm} a}}$ (10)

The height of the sole is given by the following relationship: $h = d + 5\ cm$
Where d is the useful height of the sole, determined by the relationship:
$d = \max[A - \frac{a}{4}; B - \frac{b}{4}]$ (11)

Digital application

• The dimensions of the soles determined with the use of the permissible stress values (σ_{adm}) of the soil obtained by means of the resistance to dynamic penetrometer are:

$$B_T = \sqrt{\frac{980\ kN.20}{\frac{281 kN}{m^2}.15}} = 2.16\ m$$

$$A_T = \frac{15}{20} cm\ x2.16 = 1.62\ m$$

$$H_T = \max\left[162\ cm - \frac{15\ cm}{4}; 216\ cm - \frac{20\ cm}{4}\right] + 5cm = 54\ cm = 0.54\ m$$

• The dimensions of the soles determined with the use of the permissible stress values(σ_{adm}) obtained using the model are:

$$B_M = \sqrt{\frac{980\ kN.20}{\frac{288 kN}{m^2}.15}} = 2.14\ m$$

$$A_M = \frac{15}{20} cm\ x2.13 = 1.60\ m$$

$$H_T = \max\left[160\ cm - \frac{15\ cm}{4}; 213cm - \frac{20\ cm}{4}\right] + 5\ cm = 54\ cm = 0.54\ m$$

The differences between the dimensions are as follows:

- A_T and $A_M$is 0.02 m, or 20 cm;
- B_T and B_M is 0.02 m, or 20 cm;
- H_T And H is 0.00 m, or 0 cm.

The dimensions of these soles were calculated for 10 cases of different bearing soils, using the results of the dynamic penetrometer test. For this purpose, the resistance to the dynamic penetrometer obtained in the field on the one hand and the resistance to the dynamic penetrometer determined by the model on the other. Results from 10 different sites are presented in Table 4.

Table 4: Comparison of soles dimensions obtained using experimental σ_{adm} and model-determined σ_{adm}

Nº	Depth	ω (%)	e	R_{Pdyn} Field (bars)	R_{Pdyn} Model (bars)	σ_{adm} Field	σ_{adm} Model	Field : Dimensions of sole (m)			Model : Dimensions of sole (m)			Deviation (m)		
								A	B	H	A	B	H	A	B	H
1	2.50m-3m	12.7	1.12	56.22	57.52	2.81	2.88	1.62	2.16	0.55	1.60	2.13	0.55	0.02	0.02	0.00

2	1-2m	27.7	1.45	12.70	13.84	0.64	0.69	3.40	4.54	1.15	3.26	4.35	1.10	0.14	0.19	0.05
3	4-5m	20.5	1.67	26.00	26.21	1.30	1.31	2.38	3.17	0.80	2.37	3.16	0.80	0.01	0.01	0.00
4	1-2m	18.2	1.64	23.36	25.06	1.17	1.25	2.51	3.34	0.85	2.42	3.23	0.85	.09	0.12	0.00
5	3-5m	11.8	1.02	73.41	69.28	3.67	3.46	1.42	1.89	0.50	1.46	1.94	0.50	0.04	0.06	0.00
6	4-5m	22.8	1.39	26.08	28.51	1.30	1.43	2.37	3.17	0.80	2.27	3.03	0.80	0.10	0.14	0.00
7	2.65-4m	22.6	1.69	29.02	26.43	1.45	1.32	2.25	3.00	0.80	2.36	3.14	0.80	0.11	0.14	0.00
8	3-4m	16.4	1.38	38.72	35.63	1.94	1.78	1.95	2.60	0.65	2.03	2.71	0.70	0.08	0.11	0.05
9	2-3m	15.1	1.01	71.75	66.57	3.59	3.33	1.43	1.91	0.50	1.49	1.98	0.50	0.05	0.07	0.00
10	3-4m	29.0	1.78	27.53	21.63	1.38	1.08	2.31	3.08	0.80	2.61	3.48	0.90	0.30	0.39	0.10

Table 4 shows that the deviations in dimensions A, B and H, ranging from 1cm to 14 cm, 1cm to 19 cm and 0 cm to 5 cm, respectively (except such isolated value of 30 cm in A, 39 cm in B and 10 cm in H) are negligible for the foundation soles.

4. CONCLUSION

The town of Amtiman, the capital of the Salamat region, is located in the south-east of Chad. Its relief is more or less flat. Its climate is of the Sahel-Sudanese type and its vegetation is mainly wooded. The model for the determination of resistance to the dynamic penetrometer of the soils of the town of Amtiman was developed using both in-situ and laboratory data. These results were processed using Math works Matlab R2013a (10). This treatment is a model for the determination of dynamic resistance, based on physical parameters (water content and void index) which are simpler and less costly to measure. Thus, the model can be used in the determination of said characteristic for the soils of the city of Amtiman.

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