

CORRELATION BETWEEN PRESSUREMETER AND OEDOMETER TESTS FOR FOUNDATION SOIL CHARACTERIZATION: CASE STUDY OF OUAGADOUGOU, BURKINA FASO

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ABSTRACT

This study analyzes the correlation between oedometer and pressuremeter tests for the characterization of foundation soils in the city of Ouagadougou. Investigations were conducted at five sites using boreholes, laboratory oedometer tests, and in situ pressuremeter tests, complemented by a comparative assessment of the settlements of a typical seven-story reinforced-concrete building (ground floor plus six stories) founded on a 789.09 m² raft foundation transmitting an actual stress of 0.118 MPa to the ground. The results reveal substantial lithological and mechanical variability in the soils. Oedometer moduli range from 70.83 to 142.08 bar, while compression indices range from 0.154 to 0.261. Settlements calculated using the oedometer method range from 3.68 to 9.40 cm at the foundation center, whereas pressuremeter estimates range from 0.45 to 3.59 cm. Correlations between the pressuremeter modulus EM and the oedometer parameters remain weak ($R^2 = 0.0184 - 0.3362$), confirming the influence of lithological heterogeneity and differences in testing conditions. In contrast, the relationship between settlements shows a moderate correlation ($R^2 = 0.573$) and an increasing linear trend. These findings indicate that the oedometer test is particularly relevant for assessing compressibility and consolidation, whereas the pressuremeter test provides information on in situ deformability. Their combined use therefore represents a relevant approach for improving geotechnical characterization and foundation settlement estimation in Ouagadougou.

Keywords: *Oedometer test; Menard pressuremeter test; Soil deformability; Foundation settlement; Ouagadougou*

INTRODUCTION

Characterizing soil deformability and compressibility is an essential step in foundation design, as settlement often represents a governing criterion for serviceability limit-state verification (Terzaghi *et al.*, 1996). This issue is particularly important in clayey and lateritic soils, whose mechanical behavior may vary considerably depending on their structure, degree of weathering, moisture condition, and stress history. In the city of Ouagadougou, characterized by rapid urbanization and significant lithological heterogeneity of foundation soils, reliable evaluation of deformation parameters is therefore necessary to prevent the risk of differential settlement in structures. Among the commonly used methods, the oedometer test characterizes soil compressibility and consolidation under vertical loading in the laboratory (NF P 94-090-1, 2021), whereas the Menard pressuremeter test provides an in-situ assessment of ground deformability and strength

(Baguelin *et al.*, 1978). Although these two tests involve different loading conditions, their respective parameters, particularly the oedometer modulus (E_{od}) and pressuremeter modulus (E_M), may provide useful relationships for geotechnical characterization and settlement estimation (Frank *et al.*, 2004). This study therefore aims to analyze and correlate the results of oedometer and pressuremeter tests performed at five representative sites in Ouagadougou. It is based on lithological characterization, determination of compressibility and deformability parameters, comparative estimation of settlements using both approaches, and the establishment of empirical relationships between their principal parameters. Specifically, the objectives are to identify the lithology of the investigated soils, determine soil deformability parameters through pressuremeter and oedometer testing, estimate settlements obtained using both methods, and establish potential correlations between the geotechnical parameters derived from the two experimental approaches.

1. STUDY CONTEXT

1.1. Location of the Study Area

This study was conducted in the city of Ouagadougou, the capital of Burkina Faso. Ouagadougou is located in the heart of the West African Sahel at approximately $12^{\circ}22'$ N latitude and $01^{\circ}31'$ W longitude, at an average elevation of 300 m above sea level (Offerle *et al.*, 2005). The city is built on generally flat terrain, with elevation differences of less than 15 m between different locations (Lindén *et al.*, 2011). This flat topography influences urban development. Ouagadougou's urban structure is characterized predominantly by low-rise buildings, generally one to two stories in residential areas. However, the downtown area includes several two- to five-story buildings, with taller structures reaching up to ten stories (Lindén *et al.*, 2011).

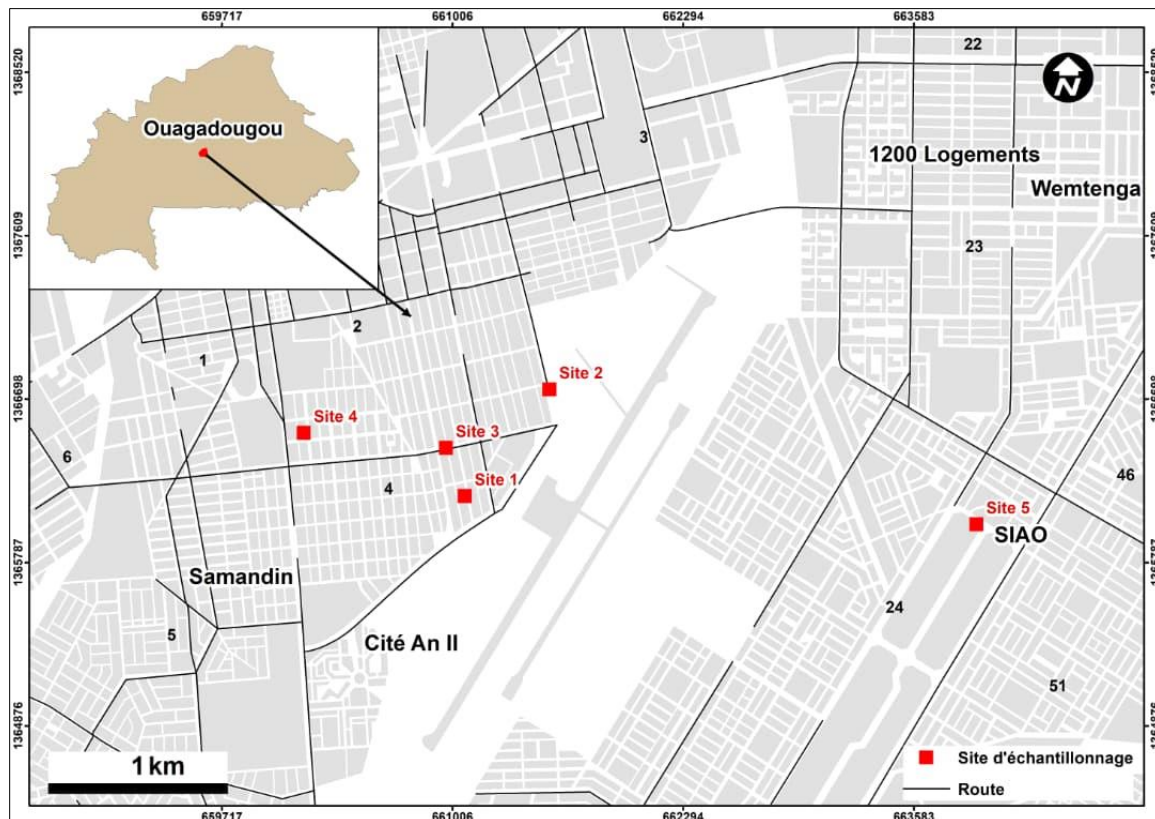


Figure 1: Location map of the study sites

The choice of this city is justified by its rapid urbanization and the persistent geotechnical challenges associated with foundation soils. Accordingly, five sites were selected for the study (Figure 1). Satellite-image analyses show rapid spatial expansion of housing throughout Ouagadougou. Numerous informal neighborhoods, commonly referred to as “unplanned areas,” are expanding on the outskirts of the city. These areas are characterized by simple dwellings made of earth and corrugated metal sheets and by an almost complete lack of modern roads.

1.2. Local Geological and Geotechnical Setting

Geologically, the city of Ouagadougou is mainly underlain by Paleoproterozoic crystalline and metamorphic formations (Castaing *et al.*, 2003). The lithostratigraphic setting is characterized by Quaternary alluvium, post-Birimian dolerites, and granitoids belonging to the Birimian basement, including granodiorites, tonalites, diorites, and plutonites (Yaméogo, 2008). This geological diversity is also reflected in considerable heterogeneity of the soils encountered throughout the city. From a geotechnical standpoint, investigations conducted in Ouagadougou indicate marked vertical variability in foundation soils. Near-surface horizons generally consist of topsoil and reworked materials, underlain by lateritic formations, particularly gravelly and indurated horizons, followed by predominantly clayey materials whose mechanical properties may be more sensitive to deformation and settlement processes (Yonli *et al.*, 2024). This lithological succession reflects the geotechnical heterogeneity of Ouagadougou's subsurface and justifies site-specific investigations prior to foundation design.

2. MATERIALS AND METHODS

Methodology

The methodology adopted in this study is based on in situ and laboratory geotechnical investigations. These tests were used to determine the main soil deformability and compressibility parameters required for settlement calculations. Calculation methods based on oedometer and pressuremeter approaches were applied in accordance with geotechnical recommendations for shallow foundations. The main stages included (i) lithological description of the soils, (ii) evaluation of soil mechanical parameters from oedometer and pressuremeter tests, and (iii) estimation of foundation settlements using the resulting data.

2.1. Lithological Description of Foundation Soils

The lithological description of the foundation soils was performed on cores recovered from core drilling. In principle, core drilling consists of drilling with a rotary core barrel. In this study, core boreholes were completed at five sites in accordance with XP 94-202 (AFNOR, 1995), using an APAFOR 450 RS drilling rig equipped with a 60-mm-diameter diamond bit. All boreholes extended to a depth of 10 m below ground surface.

2.2. Oedometer Test Procedure and Parameter Determination

- Oedometer test procedure:

The oedometer test reproduces soil deformation conditions for a horizontally layered soil mass subjected to uniform loading, in which the soil is allowed to deform only vertically. In this study, the test was performed on undisturbed specimens placed in a rigid cylindrical cell called an oedometer. The apparatus applies a vertical axial load to the specimen while its vertical deformation is measured with a dial gauge. The specimen, drained at the top and bottom through porous stones, is maintained in a saturated condition throughout the test. The load is applied in constant increments for 24 hours. The increments are successively increased and decreased according to a predefined loading program.

- Determination of oedometer test parameters:

The oedometer test produces a curve, referred to as the oedometer compressibility curve or oedometer curve, relating effective stress to void ratio. The changes in specimen height measured during the test can, for each stress increment, be related to the corresponding change in void ratio calculated using Equation (1):

$$\Delta e = \frac{\Delta H}{H_0} \times (1 + e_0) \quad (1)$$

where ΔH is the change in specimen thickness caused by an increase or decrease in stress; H_0 is the initial specimen thickness; and e_0 is the initial void ratio. $\Delta H H_0 e_0$

The oedometer curve contains three distinct segments from which the parameters related to compressibility can be determined graphically or by calculation (Equation 2): preconsolidation stress (σ'_p), recompression index (C_r), compression index (C_c), and swelling index (C_g).

$$C_i = -\frac{\Delta e}{\Delta \log \sigma'_v} \quad (2)$$

The test may also be interpreted using the strain-versus-effective-vertical-stress curve. The slope of the loading curve defines the oedometer modulus according to Equations (3) and (4): $\varepsilon = f(\sigma'_v)$

$$E = \frac{\Delta \varepsilon}{\Delta \sigma'_v} \quad (3) \quad \text{where} \quad \varepsilon = \frac{\Delta H}{H_0} \quad (4)$$

2.3. Pressuremeter Test Procedure and Parameters Determination

- *Pressuremeter test procedure:*

The pressuremeter test was performed in accordance with NF P 94-110 (AFNOR, 2000) at five different sites in Ouagadougou. The procedure consists of introducing an expandable cylindrical probe into the ground. The probe is connected to a pressure-volume measuring device, also called a pressure-volume controller, located at ground surface. The test provides a curve of applied pressure versus injected volume measured at 15, 30, and 60 s, representing the stress-strain response up to failure of the in-situ soil. Pressurized water is injected into the measuring probe, causing deformation of the surrounding soil.

- *Methodology for determining pressuremeter test parameters:*

The methodology for determining pressuremeter parameters is based on processing measurements obtained during an in situ loading test. The test makes it possible to determine three fundamental parameters: The first step consists of plotting the raw pressuremeter curve and then correcting it to remove the effects of hydraulic head, the probe's inherent resistance, and apparatus deformability. Analysis of the corrected curve reveals three successive stages: probe-soil contact, a pseudo-elastic domain characterized by an approximately linear pressure-volume relationship, and a large-deformation phase leading to soil failure. Identification of these domains makes it possible to define the range used to calculate the pressuremeter modulus and to assess the deformability of the ground.

- The pressuremeter modulus (E_M) is calculated from the slope of the pseudo-elastic portion of the corrected curve according to Equation (5). It is an essential indicator of soil stiffness and is used directly in foundation settlement calculations.

$$E_M = 2(1 + \nu) \left[V_s + \left(\frac{V_1 + V_2}{2} \right) \right] \frac{P_2 - P_1}{V_2 - V_1} \quad (5)$$

ν is Poisson's ratio, conventionally taken as 0.33;

V_s is the volume of the central cell;

P_1, V_1 are the pressure and volume corresponding to the beginning of the pseudo-elastic phase;

P_2, V_2 are the pressure and volume corresponding to the end of the pseudo-elastic range;

(P_1, V_1) and (P_2, V_2) are obtained from the range selected for calculating the pressuremeter modulus.

- The limit pressure (PL) is then determined at a volume corresponding to twice the initial cavity volume. When this volume is not reached experimentally, PL is obtained by interpolation or extrapolation in accordance with NF P 94-110-1, using Equation (6). $V_l = 2 \times (V_s + V_1) - V_s = V_s + 2V_1$

The limit pressure PL is obtained by identifying the point on the corrected pressuremeter curve for which $V = V_l$; at this point, $P = PL$.

- Creep pressure (P_f): The creep pressure P_f is obtained by graphical interpretation of the $(p, \Delta V_{60/30})$ diagram. P_f is the abscissa of the intersection of the two straight lines used to represent the $(p, \Delta V_{60/30})$ diagram, where $\Delta V_{60/30}$ is the change in volume of fluid injected into the central measuring cell between $t = 30$ s and $t = 60$ s after the beginning of the pressure increment P .

2.4. Methods for Settlement Estimation

A typical building was selected to calculate settlements at the five sites. This approach avoids interpretations related to differences in building loads from one site to another. The selected structure is a reinforced-concrete building with a ground floor and six upper stories. The building loads were evaluated, and the foundation was designed using the most unfavorable allowable bearing pressure among the five sites. Table 1 presents the main design results used for settlement calculations.

Table 1: General Geotechnical Characteristics of the Foundation

Foundation parameters used for design	
Parameter	Selected value
Structure type	Seven-story reinforced-concrete building (ground floor + 6 stories)
Selected foundation type	Raft foundation
Bearing soil	Dense, slightly kaolinized gravelly lateritic clay
Foundation embedment depth	2,5 m
Allowable bearing pressure considered (σ_a)	0,15 MPa
Summary of loads applied to edge and interior columns	
Parameter	Selected value
Number of edge columns	52
Service loads on edge columns (SLS)	73 744,84 kN
Ultimate loads on edge columns (ULS)	102 171,16 kN
Number of interior columns	6
Service loads on interior columns (SLS)	17 524,74 kN
Ultimate loads on interior columns (ULS)	24 310,74 kN
Geometric characteristics, raft loading, and stability verification	
Total raft area	789,09 m ²
Raft length (Ly)	29,70 m
Raft width (Lx)	24,55 m
Raft thickness (ht)	0,88 m
Total service load on raft (Q)	1 972,72 kN
Permanent load on raft (G)	17 359,98 kN
Total load transmitted to the soil	93 077,54 kN
Actual stress applied to the soil (σ actual)	0,118 MPa
Stability verification	($\sigma_{réel} < \sigma_a$) : stability verified
Methods used for settlement calculation	Pressuremeter and oedometer methods

2.4.1. Settlement Estimation from Oedometer Tests

Settlement calculation using the oedometer method is based on compressibility parameters obtained from laboratory tests performed on undisturbed soil samples collected at the different study sites. In this method, total settlement beneath a shallow foundation is determined using the layer-by-layer approach, assuming that the compressible soil mass is subdivided into several elementary layers of thickness H_i ($H_i \leq 1$ m). Depending on the consolidation state of the deposit, one of the following formulas is used to calculate settlement.

- Normally consolidated soil: In this case $\sigma_v'{}_0 = \sigma_p'$, the settlement is given by:

$$\Delta H = \frac{C_c}{1+e_0} \log\left(\frac{\sigma_p' + \Delta\sigma'}{\sigma_p'}\right) H_0 \quad (7)$$

ΔH : the settlement of the compressible soil layer; C_c : the compression index; e_0 : the initial void ratio; $\sigma_v'{}_0$: the effective vertical stress; $\Delta\sigma'$: the stress increase induced by the structure; and H_0 : the initial thickness of the compressible layer.

- *Overconsolidated soil: In this case $\sigma_v'{}_0 \leq \sigma'_p$, the settlement is given by:*

$$\Delta H = \frac{C_r}{1+e_0} \log\left(\frac{\sigma'_p}{\sigma_v'{}_0}\right) H_0 + \frac{C_c}{1+e_0} \log\left(\frac{\sigma_v'{}_0 + \Delta\sigma'}{\sigma'_p}\right) H_0 \quad (8)$$

ΔH : the settlement of the compressible soil layer; C_c : the compression index; e_0 : the initial void ratio; $\sigma_v'{}_0$: the effective vertical stress; $\Delta\sigma'$: the stress increase induced by the structure; H_0 : the initial thickness of the compressible layer; C_r : the recompression index; and σ'_p : the preconsolidation stress. When applicable $\sigma_v'{}_0 \geq \sigma'_p$, the following relationship may be used:

$$\Delta H = \frac{C_r}{1+e_0} \log\left(\frac{\sigma'_p}{\sigma_v'{}_0}\right) H_0 - \frac{C_c}{1+e_0} \log\left(\frac{\sigma_v'{}_0 + \Delta\sigma'}{\sigma'_p}\right) H_0 \quad (9)$$

- *Underconsolidated soil: In this case, pore pressure has not been completely dissipated and the effective vertical stress $\sigma_v'{}_0$ is lower than the stress corresponding to the final equilibrium consolidation state. Settlement is evaluated using Equation (10):* $\Delta H = \frac{C_c}{1+e_0} \log\left(\frac{\sigma_v'{}_0 + \Delta\sigma'}{\sigma_v'{}_0}\right) H_0 + \Delta H_r \quad (10)$

ΔH where S_i is the settlement of the compressible soil layer; C_c : the compression index; e_0 : the initial void ratio; $\sigma_v'{}_0$: the effective vertical stress; $\Delta\sigma'$: the stress increase induced by the structure; H_0 : the initial thickness of the compressible layer in meters; and ΔH_r : the residual settlement associated with incomplete soil consolidation.

2.4.2. Settlement Estimation from In Situ Tests

According to DTU 13.12 (AFNOR/CSTB, 2015), the settlement of a shallow foundation with width B and length L is the sum of the spherical and deviatoric settlement components and is given by the following expression:

$$- S_c: \text{consolidation settlement: } S_c = \frac{\alpha}{9E_M} (q - \sigma_{v0}) \lambda_c B \quad (11)$$

$$- S_d: \text{deviatoric settlement: } S_d = \frac{2}{9E_M} (q - \sigma_{v0}) B_0 \left(\lambda_d \frac{B}{B_0}\right)^\alpha \quad (12)$$

B_0 is a reference width taken as 0.6 m;

q is the vertical pressure corresponding to serviceability limit-state load combinations;

σ_{v0} is the total vertical stress due to the weight of the soil before foundation construction;

E_M is the soil pressuremeter modulus;

α is a rheological coefficient depending on soil type;

λ_c and λ_d are shape factors dependent on the L/B ratio;

B is the foundation width;

L is the foundation length.

Details of the pressuremeter-method settlement calculation are provided in AFNOR/CSTB (2015).

3. RESULTS AND DISCUSSION

3.1. Lithology of the investigated foundation soils

The lithological profiles obtained from the soil descriptions at the different sites (Figures 4, 5, and 6) show a wide variety of soil types over depths ranging from 0 m to a maximum of 23 m. The results highlight pronounced lithological and geotechnical heterogeneity in the foundation soils of Ouagadougou, characterized by a succession of indurated lateritic horizons, lateritic clays, kaolinized sandy weathering products, saprolites, and granitoid saprock. This vertical and lateral variability directly influences the mechanical behavior of the ground. Indurated horizons and saprock generally have a greater capacity to

support loads, whereas clayey and strongly weathered formations, particularly developed at some sites, exhibit greater deformability and compressibility and may therefore promote total and differential settlement. Comparing pressuremeter and oedometer test results is thus essential for a more reliable assessment of soil behavior and deformation risks beneath foundations. These observations are consistent with the findings of Ng *et al.*, (2020), who highlighted the influence of moisture condition and structure on the hydromechanical behavior and compressibility of lateritic clays. They also agree with the conclusions of Bentil *et al.*, (2023) regarding the determining role of microstructure in material stiffness and those of Löfman and Korkiala-Tanttu (2024), who emphasized the influence of uncertainty in compressibility parameters on settlement estimation.

3.2. Deformability parameters of the investigated foundation soils

3.2.1. Deformability parameters from laboratory tests

Following the laboratory oedometer tests, compressibility curves were established for each site (Figures 2 and 3), and their interpretation provided the soil deformability parameters for the different sites (Table 2).

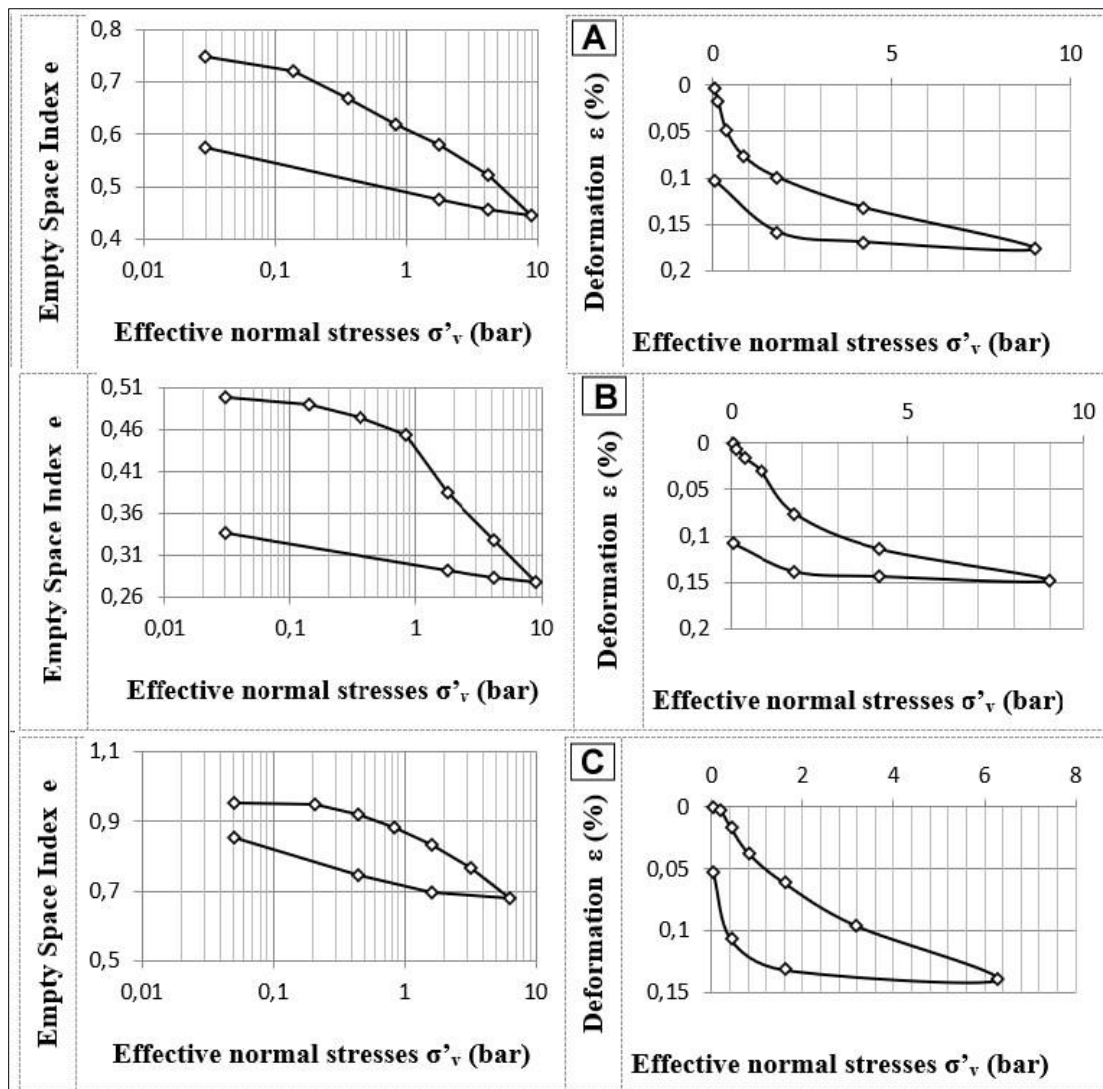


Figure 2: Compressibility curves for Site 1 (A), Site 2 (B), and Site 3 (C)

The oedometer tests performed at the five Ouagadougou sites (Figures 2 and 3) show a regular decrease in void ratio and increase in vertical deformation with increasing effective stress, while also revealing substantial variability in geotechnical parameters (Table 2). The initial void ratio, compression index, oedometer modulus, and preconsolidation stress indicate differences in stiffness, compressibility, and consolidation state among the investigated soils. Overall, the materials exhibit moderate compressibility, but Site 5 appears to be the most deformable, with a high compression index and the lowest oedometer modulus, whereas Sites 2 and 4 show greater resistance to deformation.

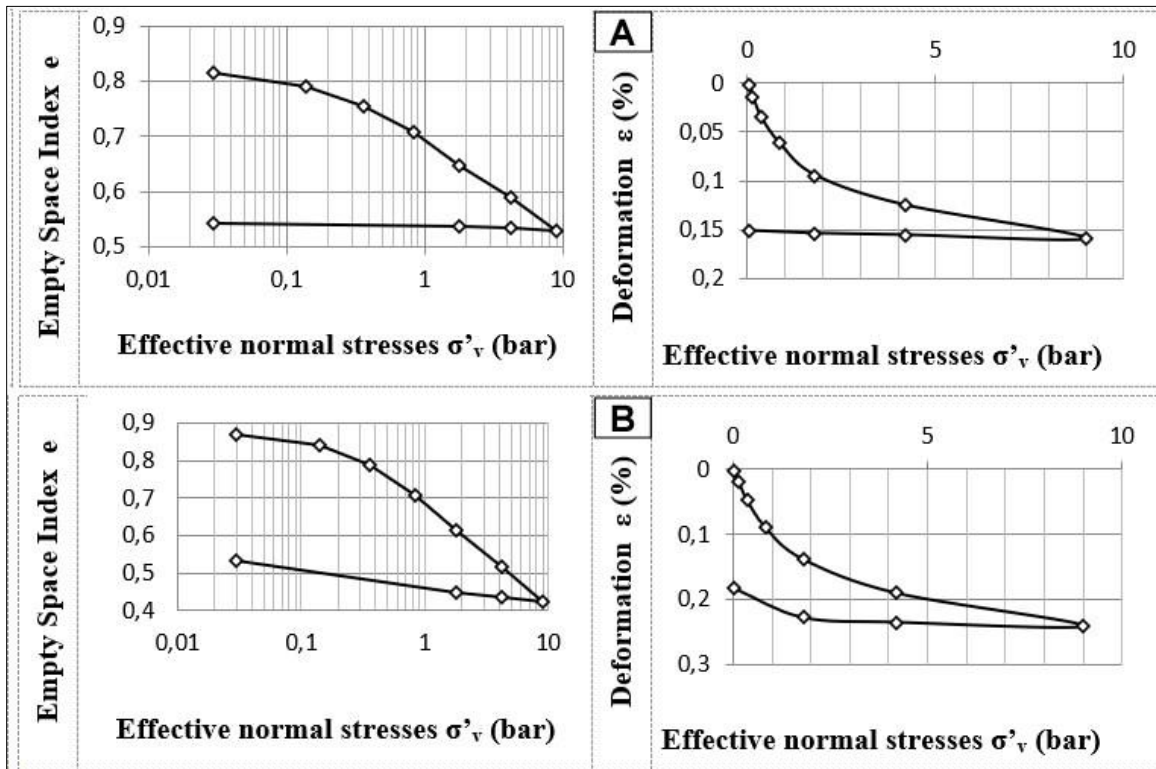


Figure 3: Compressibility curves for Site 3 (A) and Site 4 (B)

Table 2: Deformability parameters of compressible soil layers at the five investigated sites

Sites investigués	Void ratio e_0	Compression index C_c	Recompression index C_r	Preconsolidation stress σ'_p (bar)	Contrainte verticale effective σ'_{vo} (bars)	Oedometer modulus E_{oed} (bar)
Site 1	0,748	0,237	0,039	0,840	0,729	107,24
Site 2	0,499	0,154	0,013	0,840	0,758	142,08
Site 3	0,954	0,259	0,008	0,830	1,063	70,83
Site 4	0,814	0,171	0,034	0,360	0,598	140,44
Site 5	0,869	0,261	0,041	0,360	0,522	95,74

The compression-index values, which are consistent with non-expansive clayey materials (Lerau, 2006), may in particular be associated with the presence of kaolinite in several horizons. These findings are consistent with the work of Ambassa *et al.*, (2022) on the usefulness of oedometer testing for the mechanical characterization of lateritic soils and with Liu *et al.*, (2024), who emphasized the complementarity of laboratory measurements and in situ pressuremeter tests. Studies by Zhao *et al.*, (2024) also highlight the influence of microstructure and cementation on the compressibility of lateritic soils, whereas Phonchamni *et al.*, (2025) and Li *et al.*, (2025) confirm the determining role of initial condition, stress history, and soil structure in settlement assessment. The variability observed among the sites therefore justifies establishing a local correlation between pressuremeter and oedometer parameters to improve estimates of foundation-soil deformability and settlement.

3.2.2. Deformability parameters from in situ tests

The Menard pressuremeter test provides a deformability parameter, the Menard pressuremeter modulus E_M , and a soil failure parameter, the Menard limit pressure P_L . Under the French National Application Standards for Eurocode 7, these two parameters can be used in the design of shallow and deep foundations and for verification of ultimate and serviceability limit states. The pressuremeter test results obtained at the five sites are presented as functions of depth in the form of $E_M = f(z)$ curves (Figures 4, 5, and 6).

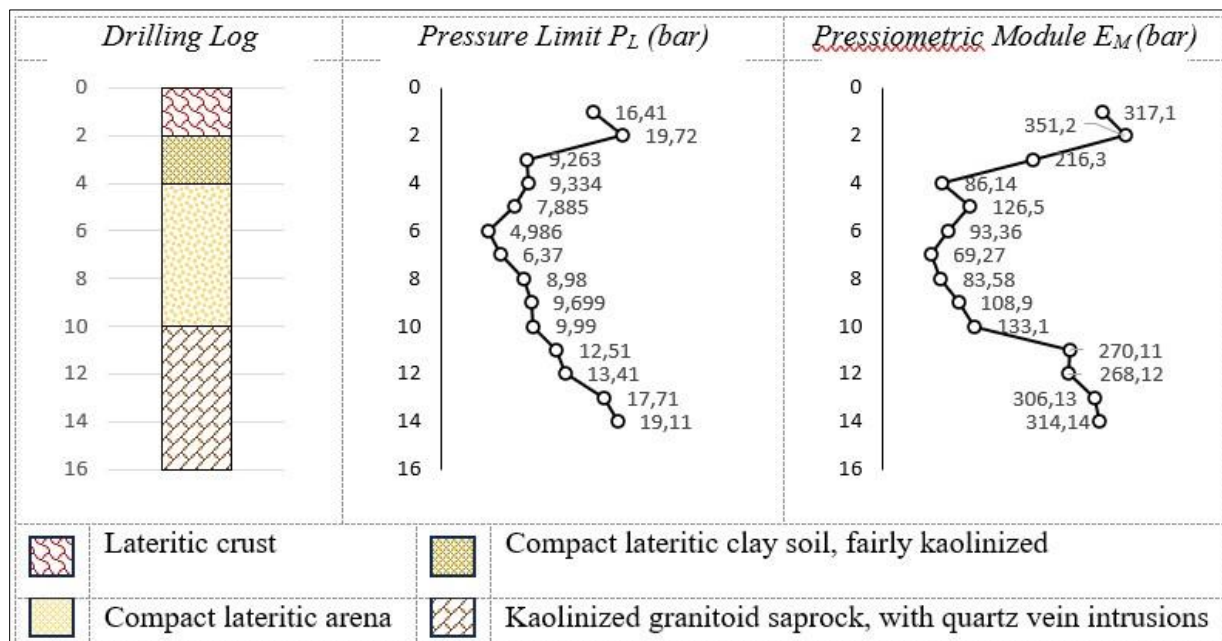


Figure 4: Pressuremeter Parameters and Associated Borehole Log for Site 1

The pressuremeter tests performed at the five sites (Figures 4 to 6) reveal substantial variability in the Menard pressuremeter modulus (E_M) and limit pressure (P_L) with depth and soil lithology. Near-surface indurated horizons, composed mainly of lateritic crusts and gravels, generally exhibit greater stiffness and resistance to deformation, whereas clayey formations, kaolinized weathering products, and saprolites have weaker mechanical properties and greater susceptibility to settlement, particularly at Sites 4 and 5. The variation of these parameters with depth reflects the determining influence of weathering degree, clay content, and compaction on soil deformability. This interpretation is consistent with Zhao *et al.*, (2024), who should be established while accounting for the lithological context and testing conditions.

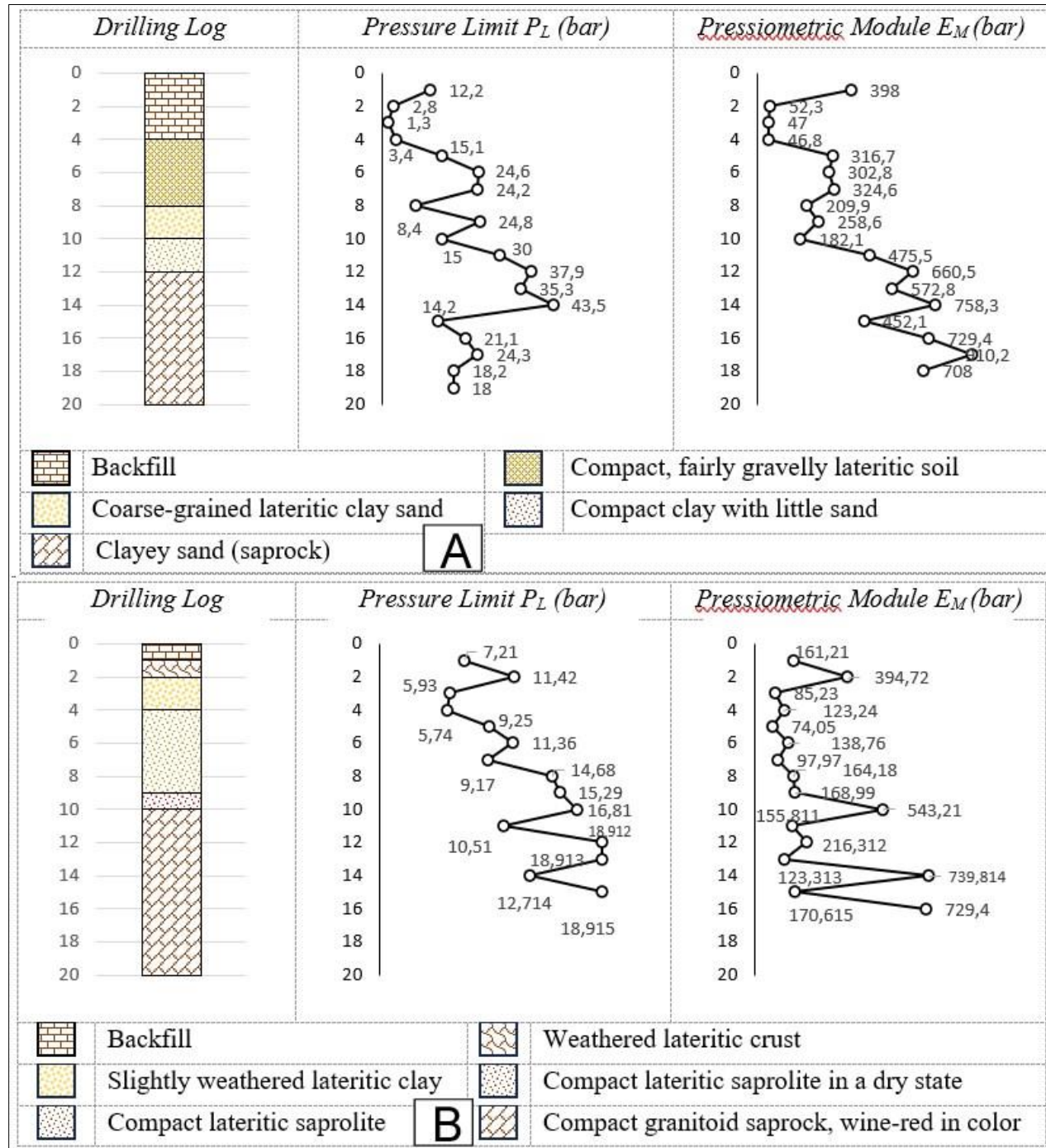
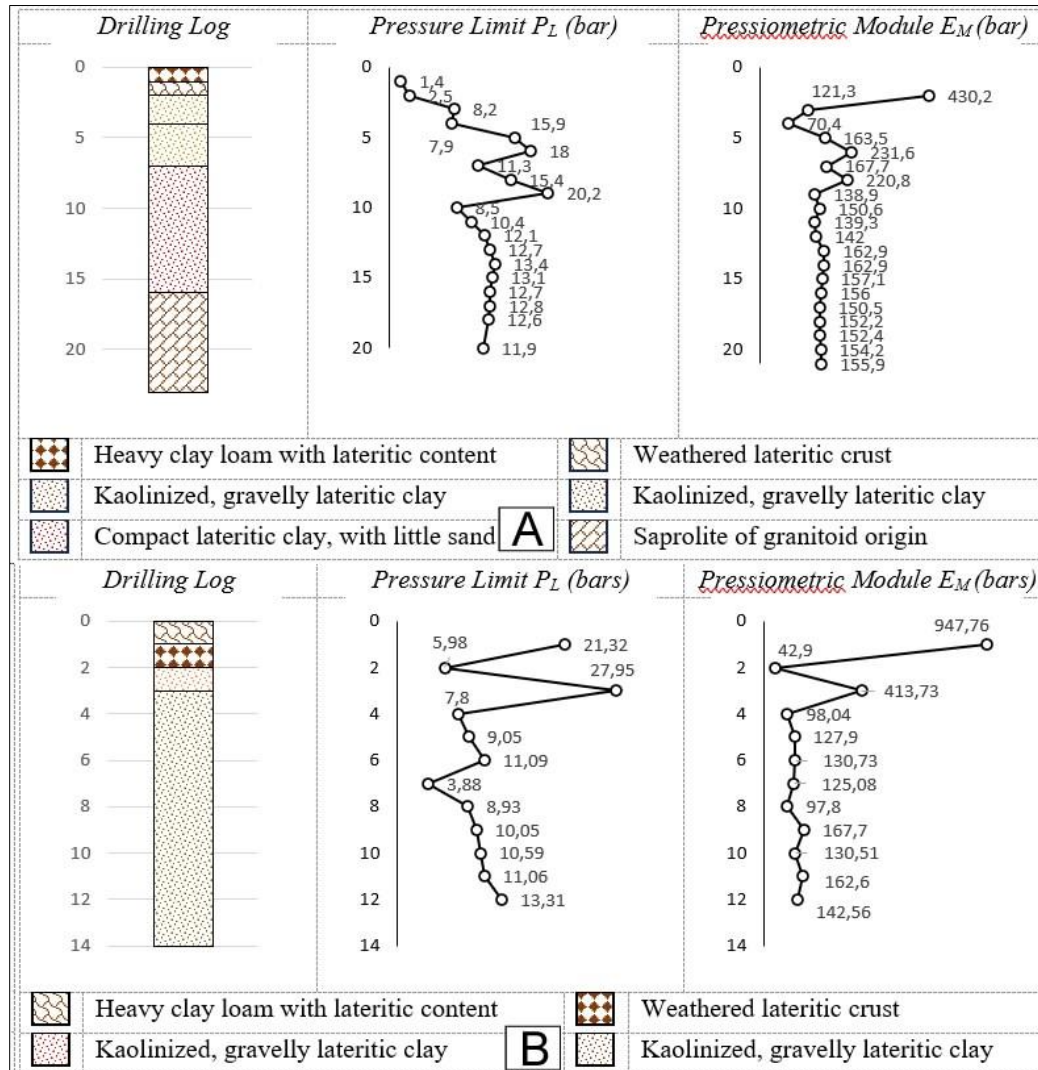


Figure 5: Pressuremeter parameters and associated borehole logs for Sites 2 (A) and 3 (B)

emphasized the role of microstructure and cementation in the mechanical behavior of lateritic soils. Comparison of pressuremeter and oedometer results is therefore particularly relevant because the two tests provide complementary information on in situ deformability and soil compressibility. However, in agreement with Chandra *et al.*, (2023) and Ambassa *et al.*, (2022), correlations between these parameters



3.3. Settlements Estimated from In Situ and Laboratory Tests

Oedometer and pressuremeter settlements were evaluated using the compressibility and deformability parameters obtained from the test results. The results are presented in Tables 3 and 4.

Table 3: Settlements calculated at the five sites using the oedometer method

Sites	Settlement at foundation corner (cm)	Settlement at foundation center (cm)	Effective vertical stress σ'_{v0} (bar)	Preconsolidation stress σ'_p (bar)
Site 1	3,99	6,78	0,69	0,84
Site 2	0,72	3,68	0,61	0,84
Site 3	1,33	5,10	0,75	0,83
Site 4	3,67	7,33	1,15	0,36
Site 5	4,43	9,40	0,35	0,36

Table 4: Pressuremeter parameters and estimated settlements at the different study sites

Sites	Menard coefficient	EM/PL* ratio	Mean EM (bar)	Shape factor		Pressuremeter settlement (cm)	Soil type	Rapport B/H
				λ_s	λ_d			
Site 1	1	16,62	143,11	1,2	1,53	3,49	Overconsolidated or very dense	1,75
Site 2	2/3	16	178,73	1,2	1,53	0,45	Normally consolidated	1,36
Site 3	2/3	16	158,28	1,2	1,53	1,50	Normally consolidated	1,64
Site 4	2/3	16	152,1	1,2	1,53	1,16	Normally consolidated	1,17
Site 5	1	18	123,13	1,2	1,53	3,59	Overconsolidated or very dense	2,05

The results show substantial variability in settlement among the five sites. Oedometer settlements (Table 3) range from 3.68 to 9.40 cm at the foundation center and from 0.72 to 4.43 cm at the corners, with Sites 1, 4, and 5 showing the largest deformations. However, they remain below the allowable values. In contrast, pressuremeter settlements (Table 4) are lower, ranging from 0.45 to 3.59 cm, with overconsolidated or very dense soils at Sites 1 and 5 and normally consolidated soils at the other sites. Thus, the oedometer method systematically produces higher settlement values than the Menard pressuremeter method because of the difference between one-dimensional compressibility assessed in the laboratory and the deformability of the soil mass measured in situ. In the lateritic clays of Ouagadougou, the oedometer test appears particularly suitable for evaluating consolidation. These findings agree with the work of Rouainia *et al.*, (2020), Liu *et al.*, (2022), and Ambassa *et al.*, (2022), as well as Mayne *et al.*, (2024) and Cheshomi and Khalili (2024), who emphasize the influence of stress state and the complementarity of laboratory and in situ testing.

3.4. Correlation Between the Two Study Methods

A comparative analysis was conducted to evaluate the consistency of parameters derived from pressuremeter and oedometer tests for settlement estimation. The correlations, expressed as fitted equations and assessed using the coefficient of determination R^2 , involve the deformability parameters E_{od} , C_c , C_r , C_g , and E_M . Examining the relationships among these parameters makes it possible to compare soil behavior in the laboratory and in situ, in accordance with Bohn *et al.*, (2013), Baguelin *et al.*, (1978), and AFNOR (2013). Limit pressure was not included because it primarily characterizes soil strength and bearing capacity. A correlation between oedometer and pressuremeter settlements was also established (Figure 7E). The results show substantial scatter in the relationships between E_M and the oedometer parameters, with very low coefficients of determination ($R^2 = 0.0184$ to 0.3362). Therefore, no robust correlation can be established across all sites, probably because of profile heterogeneity and differences between in situ bulk measurements and discrete laboratory specimens. This observation is consistent with the work of Baguelin *et al.*, (1978), Baud *et al.*, (2015), and Clarke (2022).

In contrast, the correlation between pressuremeter and oedometer settlements shows an increasing trend, with a coefficient of determination of $R^2 = 0.573$, indicating a moderate correlation. The observed differences can be explained by differences in loading conditions, scale, and deformation mode between the tests, as well as by lithological heterogeneity. These results are consistent with the conclusions of Huang *et al.*, (1991), Rouainia *et al.*, (2020), Akkaya (2019), and Tolooiyan *et al.*, (2021), who emphasize the influence of local conditions and the need to calibrate empirical relationships. The relationship obtained (Equation 13) is therefore specific to the soils investigated in Ouagadougou and should be used cautiously for settlement prediction, in accordance with the recommendations of Ambassa *et al.*, (2022).

$$S_{press} = 0.4932 S_{oedo} - 1.1468 \quad (13)$$

where Spress and Soedo are the settlements obtained by the pressuremeter and oedometer methods, respectively.

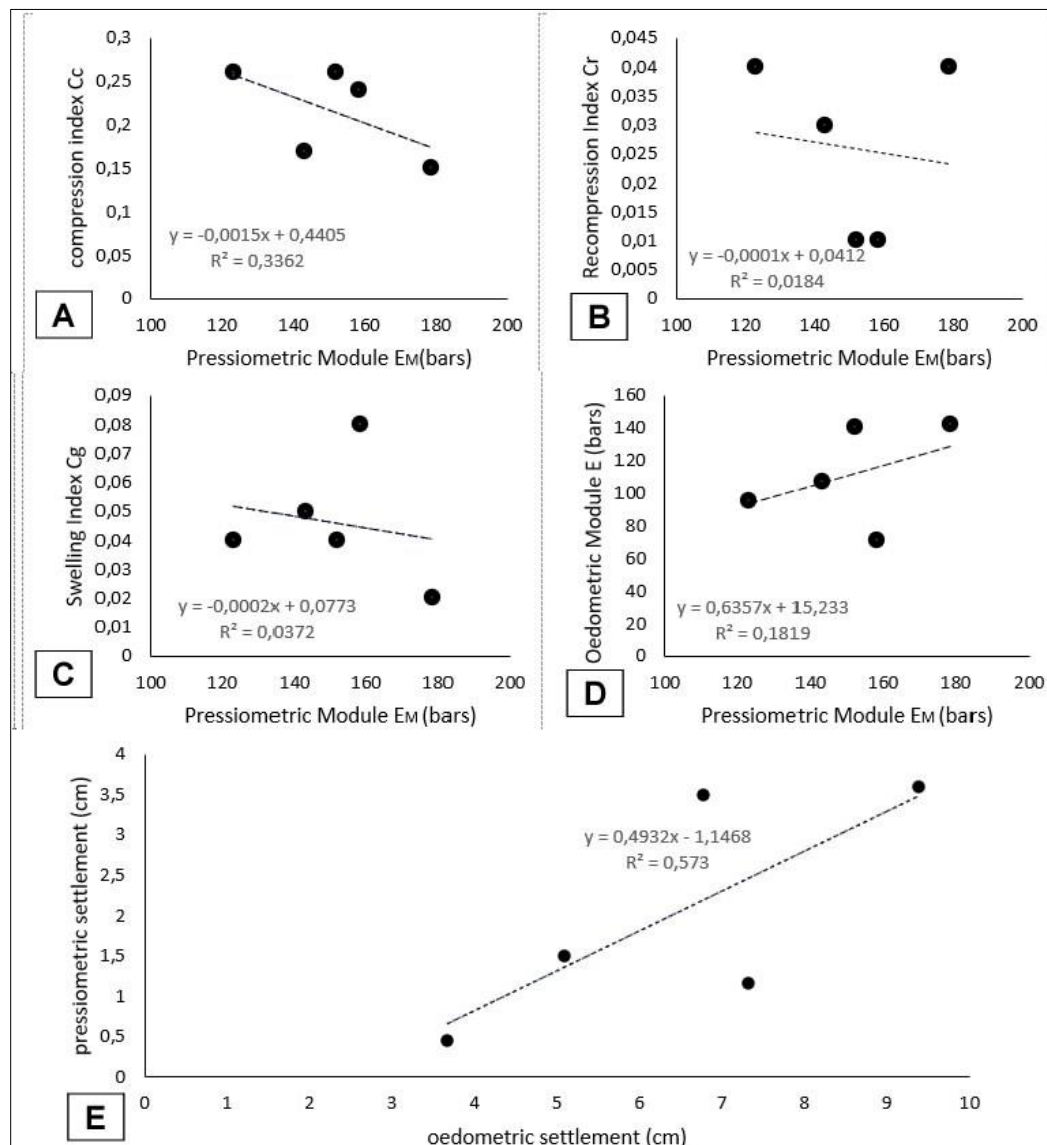


Figure 7: Correlation plots between geotechnical parameters considering the five investigated sites (A, B, C, and d) and between settlements (E)

CONCLUSION

This study evaluated and compared the deformability of foundation soils at five representative sites in Ouagadougou using oedometer and pressuremeter tests. The results confirm pronounced lithological and geotechnical heterogeneity, marked by alternating lateritic, clayey, kaolinized, saprolitic, and granitoid saprock formations. The oedometer parameters indicate Eoed moduli ranging from 70.83 to 142.08 bar and compression indices Cc ranging from 0.154 to 0.261, reflecting generally moderate but site-dependent compressibility. Oedometer settlements at the foundation center range from 3.68 to 9.40 cm, compared with only 0.45 to 3.59 cm using the pressuremeter method. Settlements calculated from oedometer testing are

therefore systematically higher than those derived from pressuremeter testing, reflecting the difference between one-dimensional compressibility measured in the laboratory and the overall deformability of the soil mass measured in situ. Direct correlations between EM and the oedometer parameters remain weak, with coefficients of determination ranging from 0.0184 to 0.3362. In contrast, the correlation between settlements obtained by the two methods is moderate ($R^2 = 0.573$), corresponding to 57.3% of the explained variance, according to the empirical relationship $S_{press} = 0.4932 S_{oedo} - 1.1468$. However, this relationship should remain specific to the geological context of Ouagadougou. The study therefore confirms that oedometer and pressuremeter tests are complementary rather than interchangeable and that comparing their results improves the reliability of geotechnical assessment and foundation-settlement prediction.

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