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VARIATIONS IN PRESSUREMETER MODULUS (E_M)

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ABSTRACT: The modulus E_M is frequently used in the design of foundations to estimate the displacement of geotechnical structures, for loaded foundations, flexible earth retaining structures, and even as a first assessment for embankment lying on compressible soil. One of the main parameters that interpreted from Menard Pressuremeter test is the elastic modulus. Different methods been used to explore the values of E_M from pressuremeter tests, in the present paper three methods utilized to interpret the pressuremeter tests modulus that conducted in a site in Abu Dhabi. The methods showed great discrepancies in the deduced values of the elastic modulus for the same tests. The differences in the results may reach to 80%, the present study also suggested a reliable method of analysis for the pressuremeter modulus.

Keywords: Pressuremeter modulus, Menard method, Gibson and Anderson method, Palmer method

1. INTRODUCION

Menard pressuremeter is one of in situ testing that generates useful information about the strength and deformation properties of any soil and weak rock. Menard pressuremeter tests performed in clay and silt soil [1] the strain controlled tests generally yield slightly higher E_M than the stress controlled , these differences could not be explained only by the time dependency of E_M , other elements, probably related to loading pattern specific to each method, must be considered, but whatever the reason, it is important to note that for the soils considered these differences remained small and not very significant .

The effect of changing the rate of strain of pressuremeter tests investigated on clay soils on undrained parameters [2] .Four rates of strain were employed to explore the effects on undrained parameters of the clay soil. The results showed that the values of pressuremeter modulus (E_M) were sensitive to the rate strain tests, the pressuremeter modulus values explored distinctive increase with increasing the rate of strain of pressuremeter testing and showed lower values with low rate of strain. The small strain modulus as calculated from the shear wave velocity determined from seismic surface wave methods were compared with intermediate strain modulus directly measured by the pressuremeter test [3]. The results showed that the ratio of small stain modulus to pressuremeter modulus was relatively consistent. Menard pressuremeter tests were conducted [4] and compared the results of the elastic modulus with standard penetration test (SPT) blow counts (N_{60}) where N_{60} represents the corrected blow count for SPT; they proposed empirical equations to determine the elastic from (N_{60}). The interpretation of the pressuremeter modulus extensively examined in present paper using different methods of analysis, in particular an attempt is made to demonstrate that the pressuremeter can explore reliable values of the elastic modulus, three methods of evaluation the pressuremeter modulus been utilized, the methods showed great discrepancies in the results for the same tests, one of these methods selected to give reliable values of the pressuremeter modulus.

2. THE PRESSUREMETER MODULUS E_M

The pressuremeter tests offer the calculation of the elastic modulus of the soil.

The equation for radial expansion of a cylindrical cavity in infinite elastic medium as presented by [5] as

$$G=V. (\Delta P/\Delta V) \quad (1)$$

Where

G= the shear modulus
V= the volume of the cavity
ΔP=difference in pressure in the cavity
ΔV=difference in the volume of the cavity

For the pressuremeter test, the above equation can be used to find the shear modulus.

The following equation Proposed [6] to calculate the shear modulus from P-V curve as can be seen in Fig.1 as follows

$$G_M = V_m. (\Delta P/\Delta V) \quad (2)$$

Where

V_m = the mean value of the borehole volume in the elastic part
ΔP= difference in pressure in the borehole
ΔV =difference in the volume of the borehole

To convert the shear modulus G_M to Young's modulus, the following well know relation is used

$$G_M = E_P / 2(1+\nu) \quad (3)$$

Where
E_P = Modulus of deformation
ν = Poisson 's ratio

Another method of interpretation of the elastic modulus also developed and presented [7], their solution show during the elastic phase of the expansion of the borehole at pressure above Po, the value of the Young's modulus, E_P can be written as

$$E_P = [\Delta P(1+\nu)a] / \rho_o \quad (4)$$

Where
ΔP= difference in pressure
ν = Poisson 's ratio
a= borehole diameter at pressure P
ρ_o = change in radial displacement at borehole wall

The value of E_P can be evaluated from the pressuremeter –volume curve as can be seen in Fig. 1 A solution for interpreting the tangent modulus G also presented [8] , the shear modulus G can be predicted by plotting the applied pressure P versus the strain ϵ_o ,the values of G can be evaluated by considering the slope of the tangent to the curve at ϵ_o =0 where ϵ_o represents the radial strain

$$G = 1/2(dP/d\epsilon_o) \text{ at } \epsilon_o = 0 \quad (5)$$

The Young's modulus E_P may in turn be derived using

$$E_P = 2(1+\nu)G \quad (6)$$

Such a curve P- ϵ_o to evaluate the shear modulus G can be seen in Fig.2

3. PRESSUREMETER TESTS RESULTS

The results of Menard presuremeter tests been used to evaluate the elastic modulus, the pressuremeter tests results that carried out in four boreholes in Abu Dhabi been used in present research with different depths, the soil can be classify as poorly graded sand with silt .Three methods for evaluation the elastic modulus were used in present research, these methods are as follow:

1- Menard Method
2- Gibson and Anderson Method
3- Palmer Method

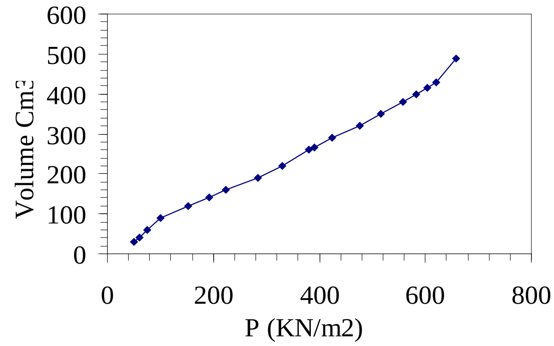

Fig.1 Pressure-volume curve BH.No.1 depth 2.3

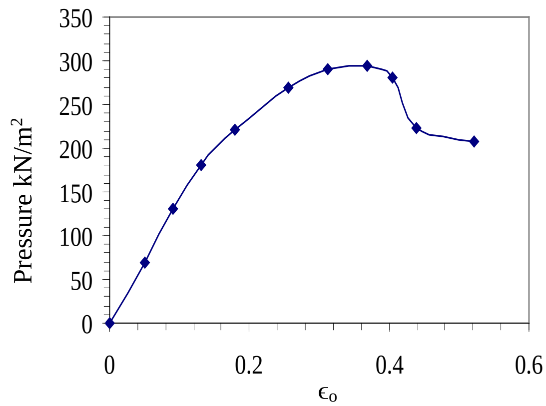

Fig.2 Pressure - ϵ_o curve for Bh.No.1 depth 4.3

4. RESULTS AND DISCUSSIONS

Menard pressure meter test results were evaluated using three methods of analysis to explore the elastic modulus. Fig.3 shows the results of the pressuremeter modulus with depths for BH.No.1, using three methods of analysis (Menard method, Gibson and Anderson method and Palmer method). There are distinctive variations in the values of the pressuremeter modulus that deduced from different methods for the same tests ,it is quite clear that the values of the elastic modulus obtained using Gibson and Anderson method are higher than those evaluated using Menard and Palmer Methods . Gibson and Anderson method showed higher values of elastic modulus than those obtained from Menard method, the increase ranged from 17% to 36% for the same tests. Gibson and Anderson also showed increases in the values of the elastic modulus than those interpreted using Palmer method, the increase ranged from 25% to 75% for the same tests. Menard method for evaluation the elastic modulus also predicts values higher than those obtained from Palmer method the increase ranged from 8% to 64% for the same tests.

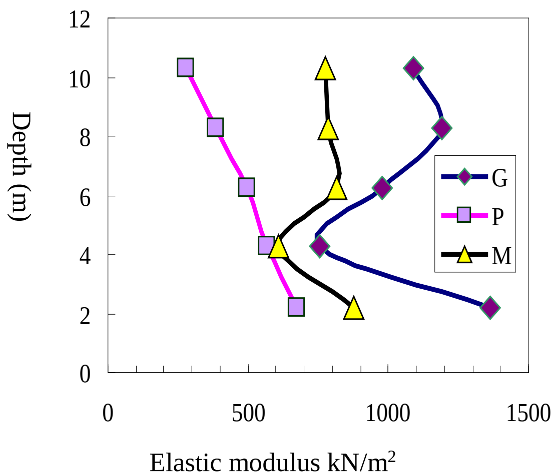

Fig.3 Variations of E_M with depth using different methods of analysis for BH.No.1 (G: Gibson and Anderson, P: Palmer, M: Menard)

Fig.4 shows the results of the pressuremeter modulus for BH.No.2, three method of analysis been utilized as follows:

1- Menard Method
2- Gibson and Anderson Method
3- Palmer Method

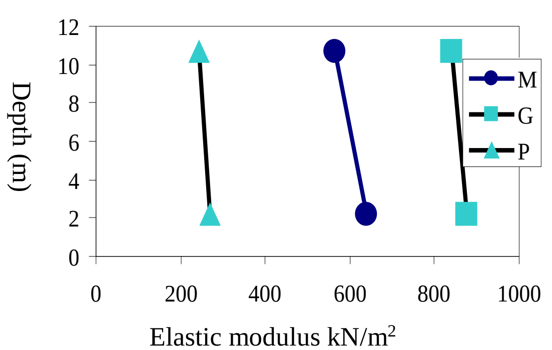

Fig.4 Variations of E_M with depth using different methods of analysis for BH.No. 2

The results showed differences in the values of the elastic modulus that deduced from different methods for the same tests ,as can be seen in Fig.4, the values of the pressuremeter modulus obtained using Gibson and Anderson method are higher than those evaluated using Menard and Palmer Methods . Gibson and Anderson method showed higher values of pressuremeter modulus than those obtained from Menard method, the increase ranged from 27% to 33% for the same tests. Gibson and Anderson also showed increases in the values of the modulus than those interpreted using Palmer method, the increase ranged from 70% to 71% for the same tests. Menard method for evaluation the modulus also predicts values higher than those obtained from Palmer method the increase ranged from 56% to 58% for the same tests.

Fig.5 shows the results of pressuremeter modulus with depth using the same three methods of analysis for BH.3. Gibson and Anderson method showed higher values of pressuremeter modulus than those obtained from Menard method, the increase ranged from 3% to 32% for the same tests. Gibson and Anderson also showed increases in the values of the pressuremeter modulus than those interpreted using Palmer method, the increase ranged from 37% to 80% for the same tests. Menard method for evaluation the pressuremeter modulus also predicts values higher than those obtained from Palmer method the increase ranged from 23% to 71% for the same tests. Fig.6 shows the results of the pressuremeter modulus with depth for BH.4, the results also evaluated by the three methods of interpretation. Gibson and Anderson method predicted values of pressuremeter modulus higher than Menard method, the increase ranged from 18% to 22% for the same tests. Gibson and Anderson also showed values of pressuremeter modulus higher than those evaluated Palmer method, the increase ranged from 46% to 60% for the same tests.

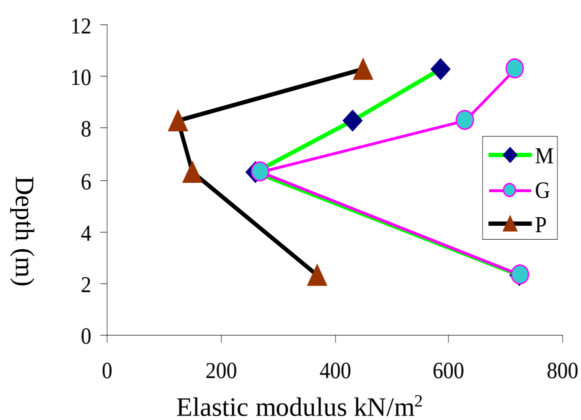

Fig.5 Variations of E_M with depth using different methods of analysis for BH.No.3

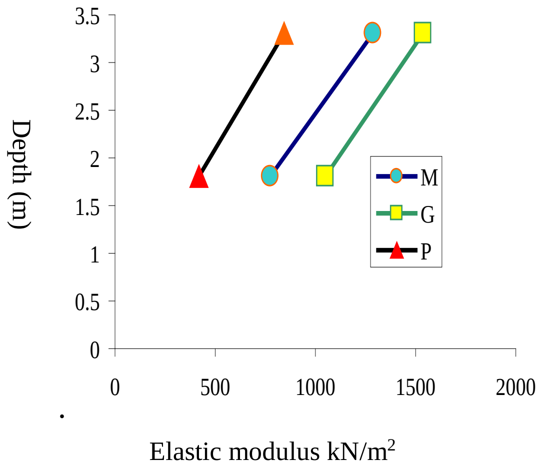

Fig.6 Variations of E_M with depth using different methods of analysis for BH.No.4

Menard method also predicted values of pressuremeter modulus higher than those obtained from Palmer method the increase ranged from34% to 46% for the same tests.

The results of pressure meter showed distinctive discrepancies when evaluated with three methods of evaluations for the same tests i.e. Gibson and Anderson method, Menard method and Palmer method, for the four boreholes, the values of the pressuremeter modulus deduced from Gibson and Anderson method are higher than those deduced from Menard method and Palmer method for the same tests. The lowest values of elastic modulus those predicted from Palmer method. Palmer method may considered as the most reliable method to predict the values of the pressuremeter modulus due to the fact that a complete stress-strain curve can be obtained and the method is free from the assumption that the soil is elastic perfectly plastic as the other methods exist in their assumptions of analysis.

5. CONCLUSIONS

The in-situ pressure meter test is a unique method to predict the soil modulus directly .The evaluation and interpretation of the elastic modulus from Menard pressuremeter tests using different methods are investigated some essential conclusions may drawn from the present research as follows:

1. Three methods of interpretations of the elastic modulus for pressuremeter testing been used ,these are :
   (a) Menard Method
   (b) Gibson and Anderson Method
   (c) Palmer Method

   The three methods predicted distinctive discrepancies in modulus values for the same tests.
2. The results of Menard pressuremeter tests from four boreholes been evaluated using the three methods of interpretation of the pressuremeter modulus, the results explored values of the pressuremeter modulus deduced from Gibson and Anderson method are higher than those evaluated from Menard method ,the increase ranged from 3% to 36% for the same tests
3. The values of the pressuremeter modulus predicted using Gibson and Anderson method for the four boreholes showed higher values than those evaluated using Palmer method the increase ranged from 25% to 80% for the same tests.
4. Menard method for evaluating the pressuremeter modulus also predicted values higher than those interpreted using Palmer method, the increase ranged from 8% to 64% for the same tests.
5. Palmer method although predicts the lowest values of the pressuremeter modulus can be considered as the most reliable method, where complete stress-strain curves can be obtained for determining the elastic modulus.

7. REFERNCES

[1] Marcil L, Sedran G and Failmezger R , “ Values of Pressuremeter Modulus and Limit Pressure Inferred From Stress or Strain Controlled Pressuremeter Testing ” 7th international Symposium on Pressuremeter ,Tunis, 2015.

[2] Alzubaidi R , “Effect of Changing the Rate of Strain of Pressuremeter Testing on Undrained Parameters” 7th international Symposium on Pressuremeter ,Tunis, 2015.

[3] Robbins D, “Initial Elastic Modulus Degradation Using Pressuremeter and Standard Penetration Test Results at Two Sites”. MSc thesis, College of Engineering, University of Nevada, Las Vegas, 2013.

[4] Cheshomi A and Ghodrati M, “Estimating Menard pressuremeter modulus and limit pressure from SPT in silty sand and silty clay soils. A case study in Mashhad”, Iran. Geomechanics and Geoengineering: An International Journal,Volume 10, Issue 3, 2015.

[5] Lame G, “Lecons le Thorie de la l Elasticitie, Gauthier Villars” Paris, 1852.
[6] Ménard L , “ Mesures in situ des propriétés physiques des sols” . Annales des Ponts et Chaussées l.3 :357-376, 1957.
[7] Gibson R and Anderson W, “In-situ measurement of soils properties with the pressuremeter”, Civ. Engng. Publ. Wks. Rev. 56: 615-618, 1961.
[8] Palmer A, “Undrained Plane – Strain Expansion of Cylindrical Cavity in Clay; Simple Interpretation of Pressuremeter Test”, Geotechnique, 22,457-451, 1972.

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