

p. 145. Interesting to see that friction angle ϕ_{DMT} is not very dissimilar from ϕ_{CPT} and, on the average (considering together low and high ϕ range), is 5% more conservative

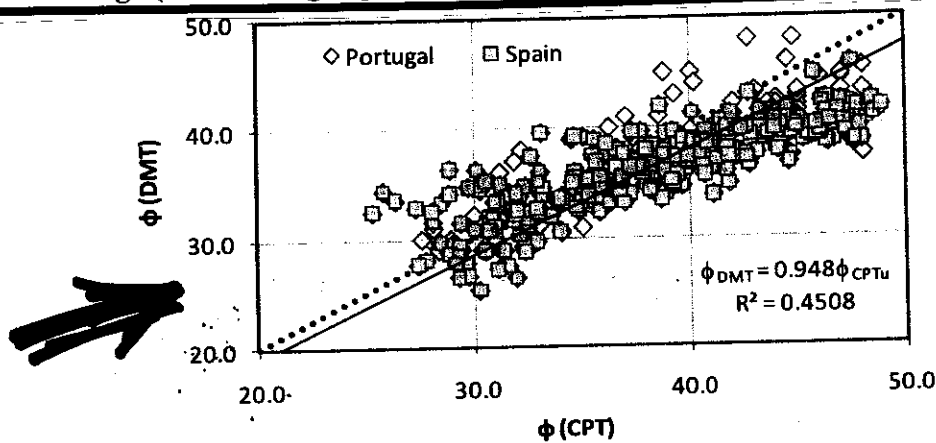


Figure 5.16 - Marchetti lower bound determination of ϕ' compared with CPTu results (Portugal and Spain)

5.5. Dilatometer modulus, E_D

Stiffness behaviour of soils is generally represented by soil moduli, and thus the base for in-situ data reduction. Generally speaking, soil moduli depend on stress history, stress and strain levels, drainage conditions and stress paths. In practice, the more commonly used moduli are constrained modulus (M), drained and undrained compressive Young modulus (E' and E_u) and small-strain shear modulus (G_0), this one being assumed as purely elastic and associated to dynamic low energy loading. In sandy soils, in-situ determinations are the only available methodologies for deducing stiffness, since undisturbed sampling in these soils is very difficult, or even impossible. In that sense, in-situ tests that measure both applied stresses and consequent deformations are mostly preferable, such as plate load, pressuremeter and dilatometer tests. S-modules in DMT or CPTu tests and CH tests are very valuable, since the determination of shear wave velocities can be directly related to small-strain shear modulus, as discussed in Chapter 4.

The determination of stiffness parameters by DMT is primarily based in the dilatometer modulus. In DMT, the usual complexity for efficient field devices to measure displacements is overcome by imposing a specific displacement through the use of Plexiglas cylinders, which remain fairly stable both with time and temperature, providing a rare accuracy in displacement determination. Theory of Elasticity is used to derive dilatometer modulus, E_D (Marchetti, 1980), by considering that membrane expansion into the surrounding soil can be associated to the loading of a flexible

p. 153 Interesting to see that just one equation (5.67) summarizes the 3 equations in Fig. 5.27 (identified by Monaco et al 2009). Maybe desirable some work to see how well it replaces the 3 interpolating equations for the 3 classes of I_D intervals, and how it follows in a continuous way the transition according to I_D .

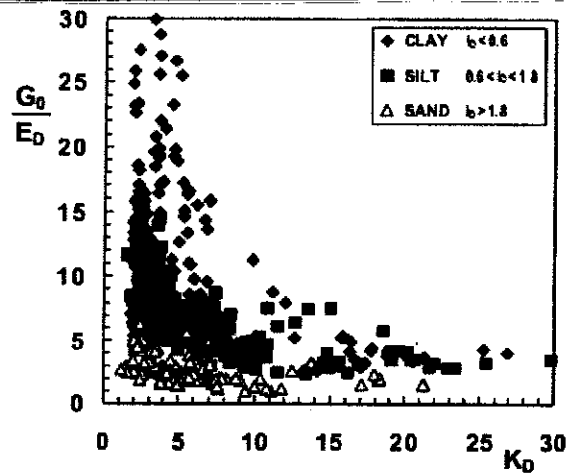


Figure 5.26 - G_0/E_D ratios as function of K_D (after Monaco et al., 2009)

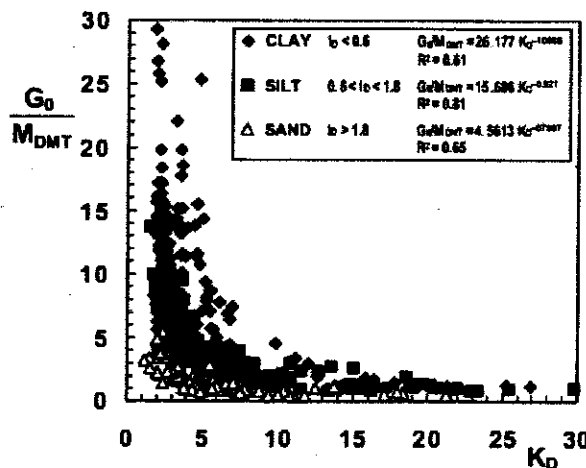


Figure 5.27 - G_0/M_{DMT} ratios as function of K_D (after Monaco et al. (2009))

The integration of these correlations under a unique equation (as function of I_D and K_D) is also possible with a few simplifications. Considering that frontier I_D values, namely 0.3 (clay-silty clay), 1.2 (clayey silts-silts-sandy silts) and 3.3 (silty sands-sands) can represent a reasonable mean, then it is possible to write the following expression:

$$G_0/M_{DMT} = a K_D^b \quad (5.67)$$

so ben interpolata il meglio di Fig. 5.27 per un'unica curva con I_D !

$$a = 31.42 e^{-0.587 I_D} \quad (5.68)$$

$$b = 1.021 e^{-0.076 I_D} \quad (5.69)$$

where a and b are the correlation factors depending on the type of soil (Figure 5.28)

414 The vertical distance between the datapoints of a new site and the 3 baseline curves (supposedly essentially sedimentary uncemented) could detect (and maybe used quantitatively) the presence of cementation (or c' intercept).

b) Upper sedimentary/lower residual bound: $G_0/M_{DMT} = 6.5 K_D^{0.691}$

c) Upper residual bound: $G_0/M_{DMT} = 33.0 K_D^{0.691}$

As a consequence of these data analysis, it becomes clear that both $[G_0/E_D \text{ vs. } I_D]$ and $[G_0/M_{DMT} \text{ vs. } K_D]$ can be used to detect the presence of cementation. Even though they can be used separately, it is suggested their combined use to have a redundant classification with the required input data coming from similar test origins same.

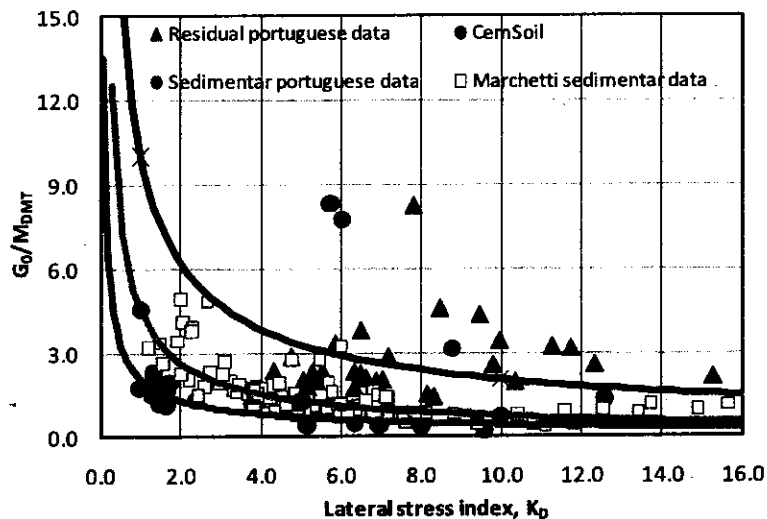


Figure 10.69 - Residual and sedimentary sand data in G_0/M_{DMT} vs. K_D space.

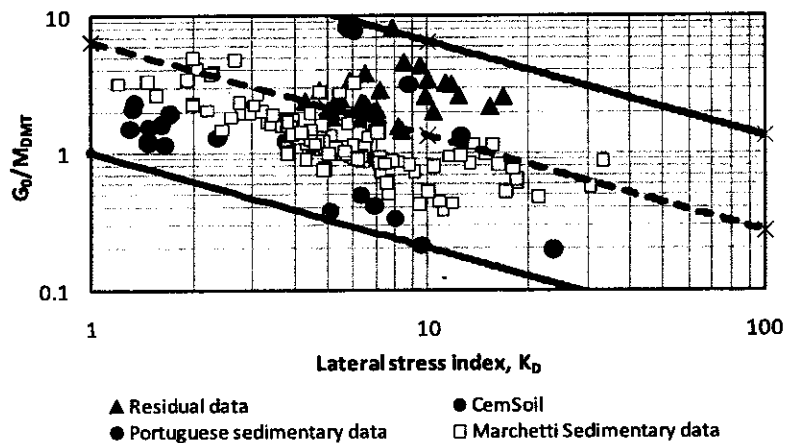


Figure 10.70 - Upper and lower bounds for residual and sedimentary sandy soils, in G_0/M_{DMT} vs. K_D plot.

j) As for in-situ state of stress of residual soils, namely K_0 parameter, the present experience could not be used for the respective parameter calibration, but the proposal (Viana da Fonseca, 1996; Cruz et al., 1997) valid for Porto and Guarda granitic residual soils ($N_{SPT} < 50$) and based in combined CPTu and DMT testing, seems to give adequate answers taking the local experience into account.

In Table 11.1 the correlations calibrated by the present experimental work are presented, showing adequacy in Guarda and Porto Granite Formations characterization, and can constitute a reference base for developing specific correlations related to residual soils of different nature or other difficult geomaterials.

Table 11.1 – Correlations for deriving geotechnical parameters in Porto Granite Formation

Stratigraphy	Material Index, I_D	Marchetti, 1980	Accurate when pushed in. The division in silty sand/sandy silt soils reflects real grain size distribution
At rest stress state, K_0	$K_0 = C_1 + C_2 \cdot KD + C_3 \cdot q_d/\sigma'_v$ $C_1 = 0.376, C_3 = -0.00172$	Baldi, 1988	Granitic residual data obtained by this methodology converges well with reference work in Porto Formation. (SBPT data)
	$C_2 = 0.095 \cdot [(q_d/\sigma'_v) / K_0] / 33$	Viana da Fonseca, 1996	
Global cohesion intercept, c'_g	$c'_g = 7.716 \ln \frac{V}{OCR} + 3.53$	Cruz, 2010	Includes suction effects, above phreatic level. M/q_t should provide similar accuracy (combined DMT+CPTU might be an useful tool for suction evaluation)
Effective angle of shearing resistance, ϕ'	$\phi'_{cor} = \phi'_{DMT} - 2.48 \ln(c'_g) - 3.12$ ϕ'_{DMT} obtained by Marchetti (1997) correlation	Cruz, 2010	Correction of Effects of suction, which are present together with effective components, above phreatic level
Service stiffness, E, M	$E = 0,8 M$ M calculated by Marchetti (1980) correlation	Marchetti, 1980	Corresponds to strain levels ranging from 10^{-3} to 10^{-4} in reference to conventional axial strain
Dynamic stiffness, G_0	$G_0/E_D = 9.771 I_D - 1.053$	Cruz & Viana da Fonseca, 2006, Cruz, 2010	Correlation calibrated by seismic CH data and confirmed by the present research results