Some Considerations about SOA-1 Summary (Alexandria 2009)

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ABSTRACT: In the SOA-1 Summary (Alexandria, 2009) Mayne et al. suggest, about Geomaterials Behaviour and Testing, some initiatives that are theoretically sharable but often inapplicable at least in Switzerland and Italy. The Author, active in this working area, explains his opinion on the matter with examples and proposals.

1 INTRODUCTION

In the SOA-1 Summary (Alexandria 2009) P.W. Mayne, M. Coop, S. Springmann, A.B. Huang and J. Zornberg, among other things, write about Geomaterials Behaviour and Testing that:
a) only multiple measurements are truly representative of an in situ test;
b) the seismic piezocone (SCPTu) must be the reference instrument for routine testing;
c) the number of experimental sites must be increased.

2 FIRST POSTULATE

In Switzerland and Italy the more popular in situ tests are the SPT moreover in the modified form (a conical point often replaces the standard sampler), the mechanical static penetration test (MCPT) and the DPL and DPSH dynamic soundings.
All these in situ tests give indeed only "one number": the point resistance.
The value of the local lateral friction (f_s) which is measured during the MCPT has, in fact, variations which are too random to be considered reliable (Togliani & Beatrizotti, 2004), while in the DPL and the DPSH a casing is only rarely used (to employ the casings render the point resistance values more reliable, especially in cohesive soils in which the results relative to the unit penetration of the casing could also be used for a preliminary evaluation of set up and drivability in the case of subsequent foundations on piles as shown in Figure 1).
In all the cases where plausible reasons make these tests necessary (problematic accessibility to investigation area, thick gravelly layers, strongly OCR soils, insufficient available budget, etc.) or when the site investigations were planned by others and it is impossible to obtain additional information, it becomes imperative to elaborate to the best the available data even based on "one number" only.

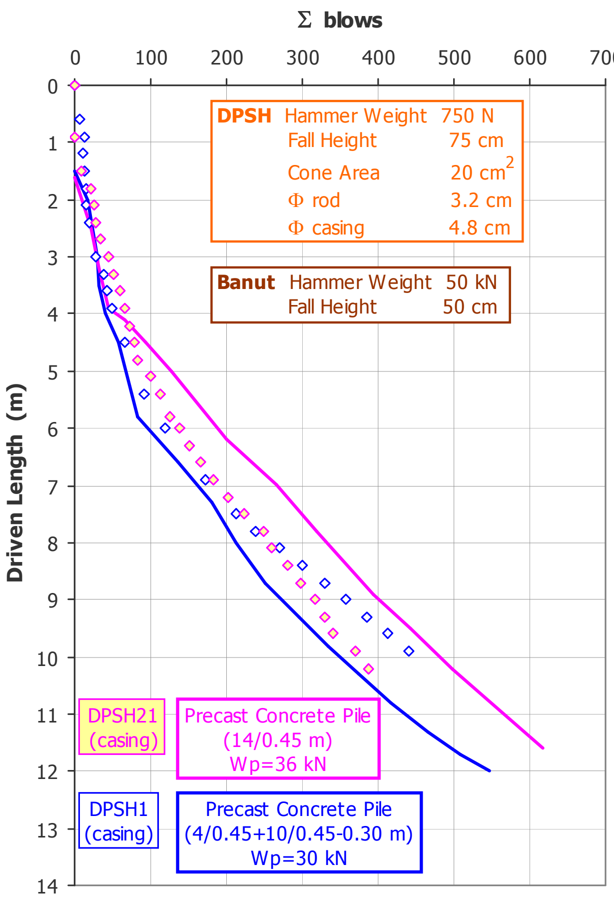

Figure 1. Mendriso (CH, 1999): Piles drivability

It is important to note that in the above mentioned countries the SPT are executed during cased borings with continuous sampling, using the following methods (Figure 2):

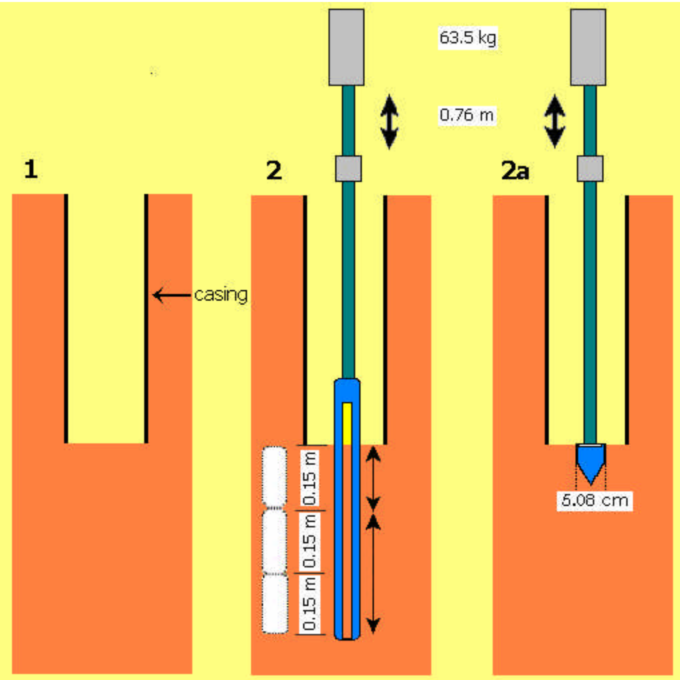

Figure 2. SPT Methods

It is therefore completely ignored the Sanglerat suggestion to deepen the hole using bentonite slurries, at least for 2.5 m (d=95 mm) to avoid the bottom hole disturbances (decompression, piping, etc.).
These phenomena can create, as in the case shown in Figure 3, a disturbed zone of a thickness that is much more than a meter (Agno, Togliani Personal Report).
As things stand, make no sense to run a standard SPT (only 0.45 m) all the more when soil samples are already present.
On this occasion it would be better to use the modified SPT (Figure2, 2a method) and to continue it for a much greater length (2 m or more) and transform the obtained reliable N_{15} values at first in dynamic resistance and then in equivalent static resistance (as in Figure 3) using the simple procedure already described by the Author (ISC'2 Proceedings), together with an application example [capacity prediction of a CFA pile (ISC'3 Presentation)].
The used conversion method is:

- *SPT* $q_c=\alpha \{(M^2H)/[Ae(m+M1)]\}$ (1)
- *DPSH* $q_c=\alpha\ (MH/Ae)$ (2)

where: M=hammer weight; m=rod weight;
M1= hammer + anvil weight;
A= cone area; e=set set per blow
H= fall height; α=0.3→1.2 (from peat to coarse or dense gravel)

In conclusion it is certainly right to highlight the limits of the "one number" tests but it would be still better to teach their correct use and, above all, that the Academicians were activated in the specific Committees to impose an executive standard for DPL and DPSH dynamic soundings that obliges the use of casings stating therefore this test as the only certifiable.

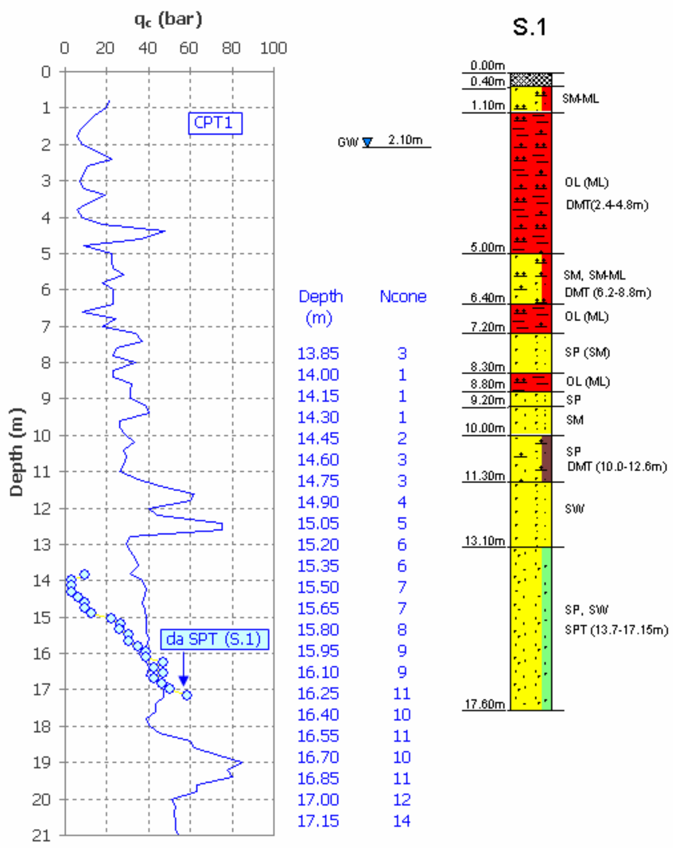

Figure 3. Agno (CH, 2009): by drilling disturbed zone

3 SECOND POSTULATE

The use of the seismic piezocone as minimum practice for a site investigation is not universally applicable, not only because sometimes this instrument either does not really exist (e.g. Switzerland) or is not sufficiently available (e.g. Italy) but because the soils for which it works best, often are below coarse layers which could compromise the integrity of the point or even impede penetration.
On this subject, it should also not be forgotten that the SCPTU by itself guarantees only a trend of the behaviour type and the derived geotechnical parameters for the soils encountered, since any anomaly in the f_s values (for example in residual soils which retain the imprint of the original structure), or of u_2 (due to the often encountered saturation deficit), or the improper choice of N_{kt} values (which can vary from 10 to 30), and/or multiplication factors of q_t to obtain the preconsolidation pressure (σ'_p) and the

confined deformation modulus (M), lead to errors which are often of major importance.
According to the Author, the minimum practice for a site investigation should therefore include, budget permitting:

- a continuous core sample drilling with frequent punctual in situ tests [SPT with a conical point in soils which are gravelly or of high consistency and DMT (which serves as a reference for the OCR, s_u and M values) in all others], in order to obtain an unambiguous interpretation key especially from the lithostratigraphic point of view (Figure 3);
- a SCPTU or alternatively a CPTU (the presence of a drilling rig would permit the carrying out of predrilling to pass through surface strata with unfavourable characteristics), integrated in this case with tomographic seismic profiles to obtain a continuous characterization of the same soils;
- identification laboratory analyses carried out on the extracted cores (volumetric weight, natural water content, Atterberg limits, grain size distribution, pocket penetrometer) for cohesive soils, which are in general those least favourable, to have fundamental information on aspects scarcely covered or lacking from the instruments mentioned above.

An example of what is written above is shown in the Figure 4 where the confined modulus depth variation demonstrates both the usefulness to derive this parameter with different in situ test and the lentiform structure of the alluvial-lacustrine deposit (the borehole S.1 and CPTU1 are 5 m away).
The Shear Wave Velocity section (Figure 5) instead shows the trend of the bedrock (not present at 38 m depth in S.1) and a shear waves velocity higher than expected for the organic soils perhaps because their slightly OC (Rivera, Togliani Personal Report).

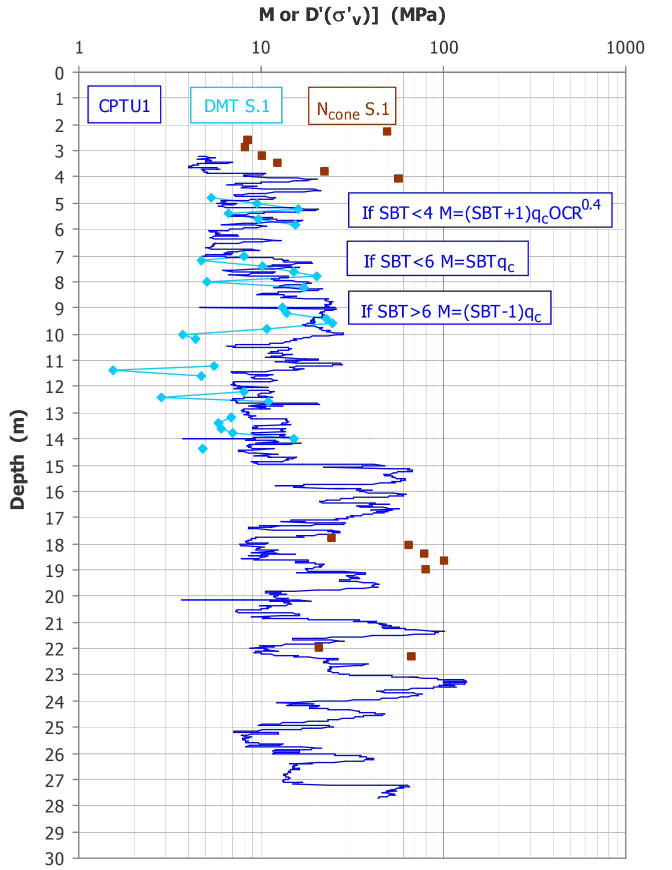

Figure 4. Confined Modulus: [Rivera (CH), 2009)

4 THIRD POSTULATE

The Author thinks that the greatest achievable increase in the development of the number of experimental sites is necessary to contrast the “daredevil” use of commercial software for CPT interpretation due to many practitioners (this obviously concerns only the geotechnical community where he works).
In fact, they too rarely verify if the equations from which the geotechnical parameters are derived are also appropriate for the local geological situation and therefore this approach is somewhat dangerous.

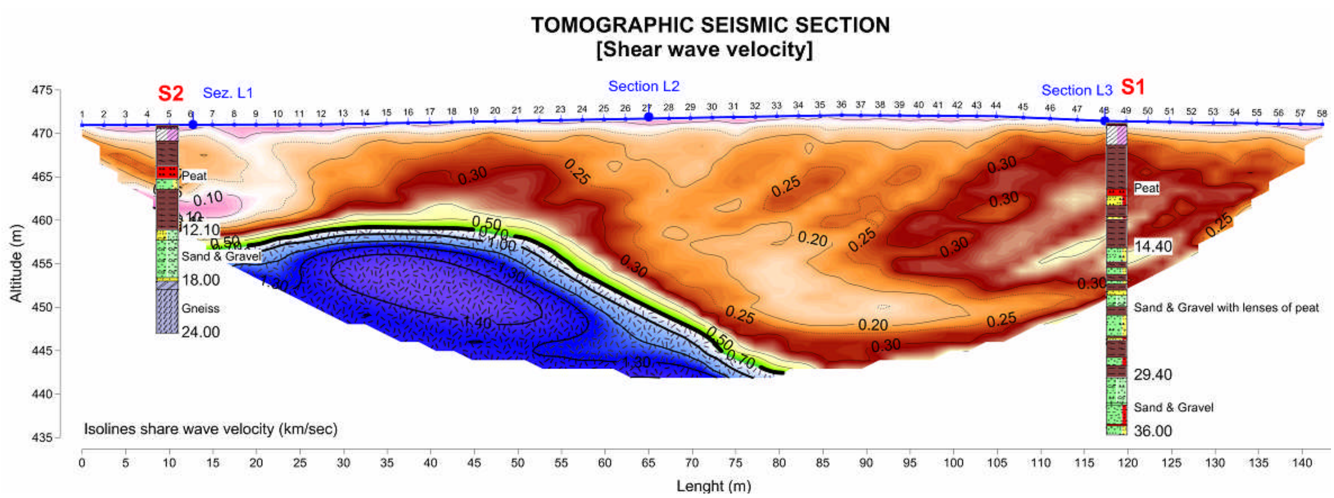

Figure 5. Shear waves section [Rivera (CH), 2009]

As a consequence, in the Author's opinion, the right solution is to create a free database, that contains CPTU, DMT, PMT, SPT interpretation examples for the greatest possible number of site in the world to allow the users to choose the one with most similar characteristic to those of their own project area.

On this subject the Author has set, as prototypes, a couple of examples referred to the experimental sites of Merville (France) for OC Clays and Stabio (Switzerland) for Mixed Soils, in which all the information (geology, litostratigraphies, interpretation of different in situ tests, comparisons among correlations, lab. analysis, disclosure graphs, etc.) were joined on Excel spreadsheets that can be provided to anyone who needs them.

In both case the used reference software was CPTe-IT, certainly one of the best on the specific matter.

The analysis of these examples allows the next considerations some of which are illustrated by graphs:

- the site's lithology is correctly detected by the Robertson Soil Charts (1986, 1990), with preference for the last one in the OC Clays. However also the Zhang & Tumay and Eslami-Fellenius methods give significant results as, after all, the I_D Chart (DMT) for the Mixed Soils;
- the undrained cohesion "s_u" should be calculated for soils classifiable as I_c> 2.58 (Jefferies & Been, 2006), at one with Ku et al. (2010). Additionally "s_u" should be calculated only when the number of the I_c values larger than 2.70 overcomes 70%. Otherwise the deposit is not sufficiently homogeneous and "s_u" shows often values and oscillations excessive to be realistic as it happens for the Mixed Soils where "s_u" has been therefore determined only for SBT $\leq$ 3 and I_D (DMT) < 0.7 (Figure 6);
- the CPTe-IT equation to calculate "s_u" is proper for the OC clay soils as that of Ladd (1991) but the last one is better and therefore recommended for the Mixed soils (Figure 6);
- the preconsolidation pressure of the OC Clays is better detected by the Robertson equation as illustrated in Figure 7, while for the Mixed Soils the recommended equation is: $\sigma'_p=0.33\,(q_t-\sigma_v)^{mp}(p_a/100)^{1-mp}$ (3) [SOA-1 Summary, 2009];
- OCR derived by oedometer (OC clays, Figure 7) is absolutely unreliable (sample disturb?);
- in OC Clays the shear waves velocities predicted by Robertson (2009) and by Andrus et al. (2003) are well correlated with that measured and consequently also the G_0 values are correctly approximated [$G_0=\rho V_s^2$ (4), Figure 9]. On the matter is interesting to notice that the chosen ASF value (Andrus et al.) is that proposed for the Holocene soils (ASF=1) despite the Flanders Clay are of the Ypresian Age (Eocene). The smectite prevalence among the clays with their "sheets" joined by weak bonds and easily separated by water, could explain a measured velocity lesser than expected in view of the high OCR and Age. This would be consistent with the low values of q_c and γ. On the other end the soil consistency is practically semisolid and this justifies the high f_s values and then the "Vs" overstatement using the f_s based equations (e.g. Mayne, NHCRP 2007) as shown in Figure 8.

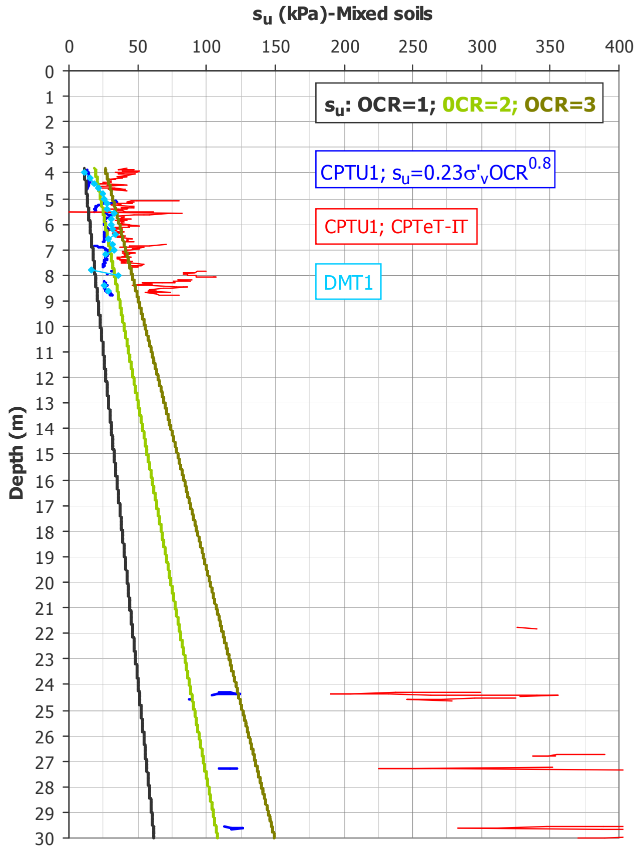

Figure 6. Undrained cohesion correlations [Stabio (CH)]

- G_0 predicted by PMT in OC clays is instead absolutely insufficient (usual disturbs tied to the execution of the hole?) as highlighted in the Figure 9;
- the CPTe-IT equation to reach the confined modulus (M or D') is reliable for the OC Clays as those proposed by Togliani (2011) quoted in Figure 4, but the latter are more secure and therefore recommended for the Mixed soils;
- the equation M=0.5 G_0 (5) allows to obtain representative values in OC Clays [the suggested equations are nevertheless: 0.05< M/G_0< 0.1 (NCHRP, 2007)];

- the CPT-DMT proposed correlations (Robertson, 2009) seem promising at least for the Mixed Soils without gravel

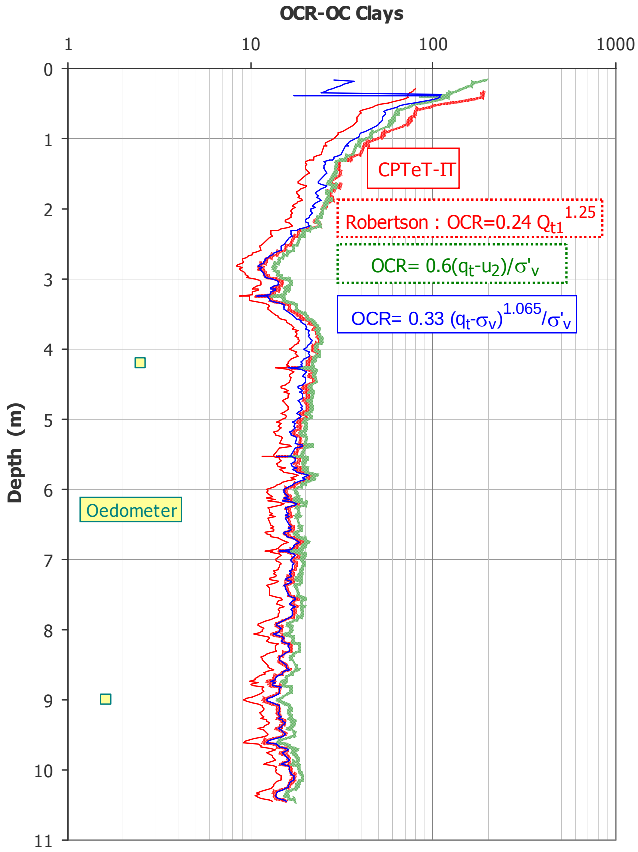

Figure 7. OCR correlations [Merville (F)]

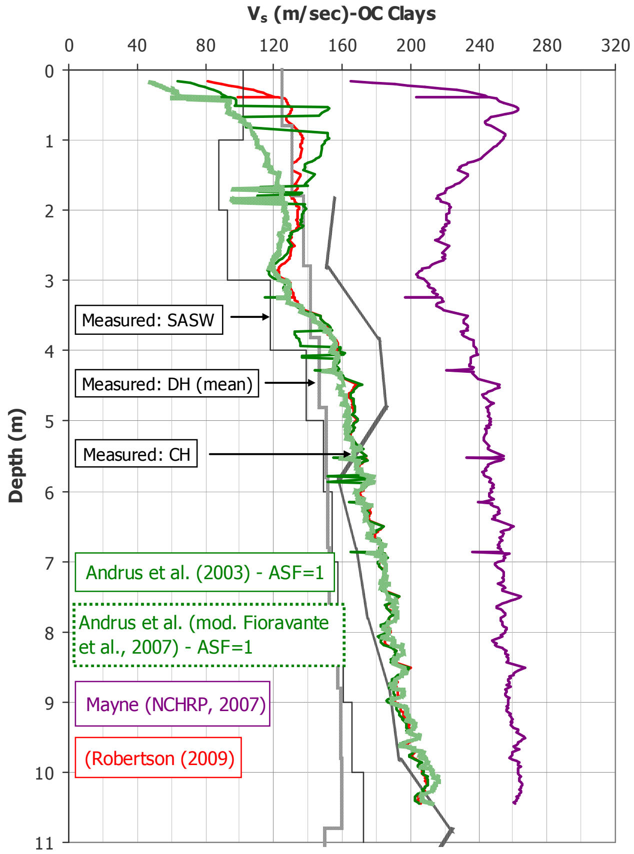

Figure 8. Measured and derived "Vs" [Merville (F)]

- the pore pressure predicted by Robertson equation shows as that measured is altered by the dilatant behavior of the OC Clays while is well approximated in the Mixed Soils (Figure 10)

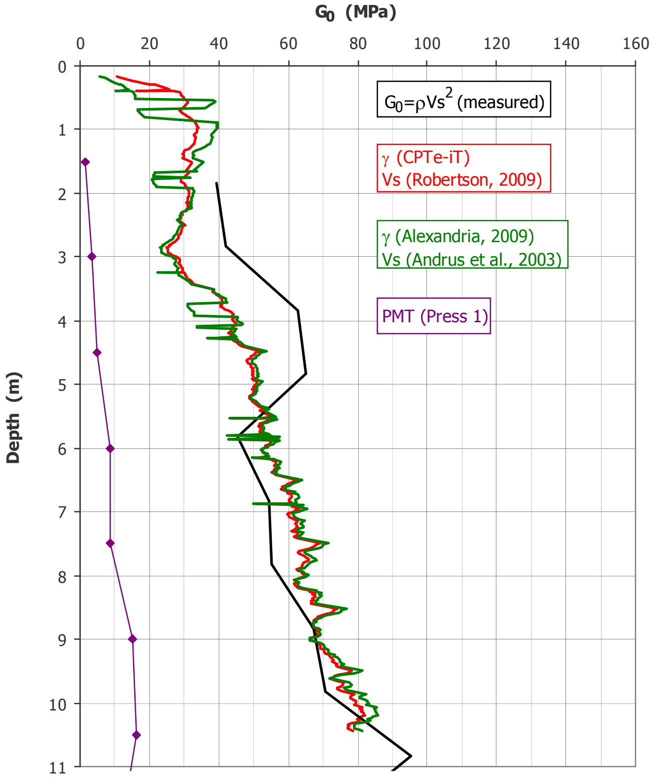

Figure 9. Measured and derived "G_0" [Merville (F)]

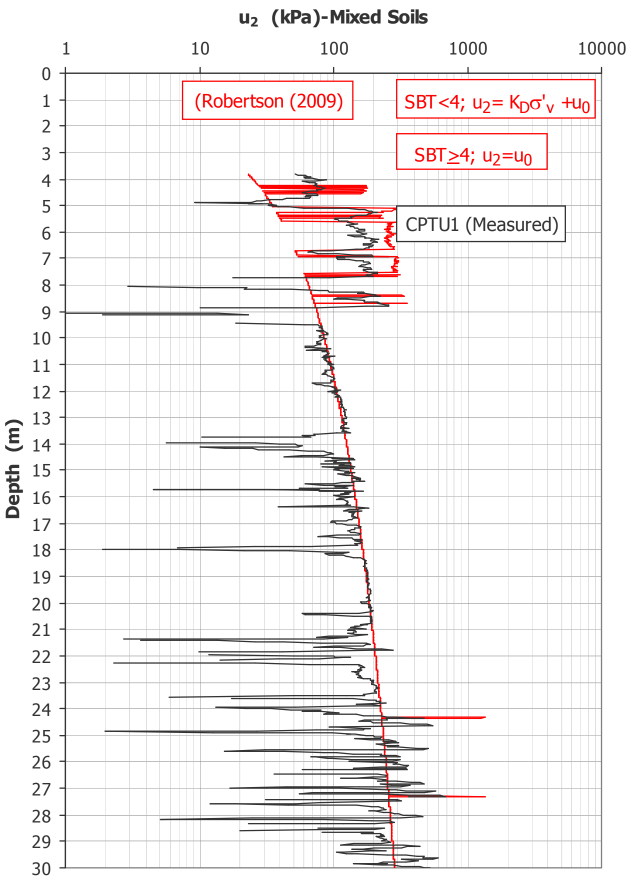

Figure 10. Measured and derived "u_2" [Stabio (CH)]

5 CONCLUSIONS

For the first two postulates the Author has tried to demonstrate that among the good proposals (SOA-1 Summary suggestions) and the daily reality, the last one must prevail because otherwise it would be lacking not only the minimum requirements for the geotechnical characterization of soils by in situ tests (at least in Switzerland and Italy) but also gradually lost the memory of what up to now has been done.

Referring to the third postulate the considerations and the explicatory graphs proposed have unequivocally shown that, to say the least, it is hasty to rely solely on commercial software, although highly professional, for the in situ test data processing.

On the matter the use of Excel spreadsheets to implement and to compare, also graphically, the results of the different equations offered by the literature and the possibility, at any moment, to easily modify the same to obtain a rapid convergence between their results and the reference values, thus respecting the local geological and geotechnical situation, provides an invaluable working tool.

However the user of this processing method is the only one that gradually acquires the sensibility to judge about the reliability of the obtained results and for this reason everyone, including AC (Academicians Community), should get their hands dirty with this exercise if they really wants to operate properly.

Only a lack of daily practice in the construction sites (starting from the checks in site investigation, continuing with the in situ tests interpretation and concluding with the inspections during the foundation works), may explain in fact that the piles capacity predictions made by AP, altogether are no different for quality from those of CC (Consultants Community).

This is indeed the surprising result of the events in which the Author has been able to participate in recent years (Orlando, 2002; Merville, 2003; Porto, 2004).

In particular about the Porto Event, Viana de Fonseca et al. (2008) wrote a very interesting book that collects the predictions of 31 participants (mainly AP) and confirm the above stated providing that for all, on the loading-movement curve, the ultimate resistance (Q_u) is the one corresponding to 10% of the pile diameter.

The comparison between the AC and CC predictions, with the further assumption that the best score is 1 (predicted equal to measured capacity), is synthesized in Figure 11.

On the matter an important benefit could be given by the *on line* availability of Case Histories even with digital data as done by Mayne et al. (e.g. Grimsby, Houston University, Euripides) that, for example, they have allowed to the Author the updating of his own method (Togliani, 2008).

Two of this paper concern bored pile both realized in OC soils where the overconsolidation is mechanical (Grimsby) otherwise due to dessication (Houston University) phenomena while the third (Euripides) relates to a pipe open ended pile.

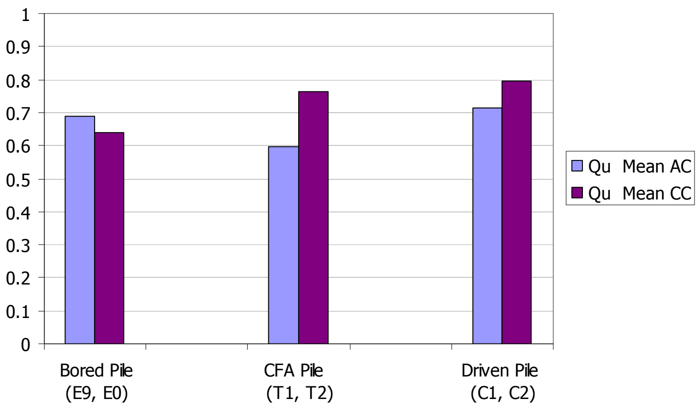

Figure 11. Piles Capacity Comparisons [Porto, 2008]

The updating is done by adding a corrective coefficient, function of OCR, for Grimsby and increasing the β coefficient in the shaft resistance equation for the Houston University Site.

The reason of these adjustments is based on the assumption, that the boring disturb is lower for the OC soils respect to NC soils instead considered in the original equation.

In the case of the Euripides site, the corrective coefficient is due to the presence, beginning from 25 m depth, of Pleistocene sand with q_t values >>30 MPa and to a pile length >30 m, never experimented before by the Author.

The above described adjustments as well the Porto pile capacity predictions, are also available on Excel spreadsheets that can be provided to anyone who would like them.

These are additional demonstrations that the free availability online of similar papers permit everyone to remain always updated so that each person can carry out their own profession in the most conscious way.

The preceding considerations induce the Author to hope that the proposed Merville and Stabio Excel spreadsheets can be a first practical example for a free database realized together by AC and CC that, following the same way, it is able to facilitate the resolution of the in situ tests interpretation problems.

About this statement he thinks in fact that, hundred of sites in the world characterized with enough approximated geotechnical information, give more benefits to all than a few dozen of perfectly known sites fully accessible only by AC.

6 ACKNOWLEDGMENTS

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