DMT DIGEST #12 DEC 91

The reader following these DIGESTs will note that an unusually long time has elapsed since DIGEST #11 dated April 1989. The Editor has had several major distractions, namely XII ICSMFE in Rio and his 25th Terzaghi Lectures and paper. Also, DMT-related publications are coming out in somewhat overwhelming numbers. However, that's an editor's problem and all the more reason for keeping up with these DIGESTs...

Item 12A - Some New References

Readers might like to note some of the new DMT-related references, including those in the Proceedings of the XII ICSMFE in Rio de Janeiro, along with mini-abstracts by the Editor. See end of text for additional references cited herein.

> Campanella, R. G. (1991) "Use and Interpretation of a Research Dilatometer", <u>Canadian</u> <u>Geotech. J.</u>, Vol. 28, pp. 113-126.

> > This paper summarizes the UBC research, in the lab and in the field, using ordinary and special research dilatometers. The authors present a variety of results of interest to DMT users and researchers. See <u>Figures 12F.1 and .2</u>, from this paper.

Garga, V. K., and Khan, M. A. (1991) "Laboratory Evaluation of K_o for Overconsolidated Clays". <u>Can. Geotech. J</u>, Vol. 28, pp. 650-659.

The authors show that the DMT gave the best K_o values in a clay crust vs. horizontal/vertical odometer method and also the SBPMT.

Hayes, J. A. (1990) "The Marchetti Dilatometer and Compressibility". Paper presented to the Southern Ontario Section of the Canadian Geotechnical Society, Seminar on In Situ Testing and Monitoring, 21-22 Sep 90, 23 pp. (contact Mr. Hayes, FAX 705-743-6854 for copy).

Unusually clear review of the DMT with emphasis for practical settlement calculations. See <u>Figure 12A.1</u>, from this paper.

Hryciw, R. D. (1990) "Small-Strain-Shear Modulus of Soil by Dilatometer", ASCE Journal GED, November, Vol. 116, No. 11, pp. 1700-16.

> The author collected G_{max} and DMT data from nine previously published test programs, in a considerable variety of soil types. He developed a correlation using only DMT data that gave an average G_{max} prediction error of 23%, which he considered understandable and acceptable.

Kabir, M.G., and Lutteneger, A.J. (1990) "Insitu Estimation of the Coefficient of Consolidation in Clays", <u>Canadian</u> <u>Geotechnical Journal</u>, Vol. 27, pp. 58-67.

Piezoblade (DMT blade with piezometer) and CPTU dissipation tests performed in four clays and compared with lab c_h and c_v data. Good comparisons obtained. The DMT tests take longer than CPTU tests. (see item 12K)

Kulhawy, F., and Mayne, P. (1989) "Manual on Estimating Soil Properties for Foundation Design" Final Draft, Project 1493-6 by Cornell Univ. for Electric Power Research Institute, March.

> Comprehensive review of insitu test theory, results, and recommendations for practice. Includes SPT, CPT, CPTU, DMT and PMT, and summary tables for comparative applicability and accuracy of these different insitu tests, in the judgement of the authors at the time of preparing their report, reproduced here as Table 121.1.

Larsson, R., and Eskilson, S. (1989) "Dilatometerforsok i Lera (DMT Investigations in Clay)" and "Dilatometerforsok i Organisk Jord (DMT Investigations in Organic Soils)", Swedish Geotechnical Institute <u>Publication</u> <u>Nos. 243</u> in Feb. and <u>248</u> in Aug, respectively.

Larsson, R. (1989) "Dilatometerforsok" Swedish Geotechnical Institute, <u>Information 10</u>, Dec, 58 pp. Mostly summary of #243 and #248.

> DMT sounding results at nine sites, including five with organic soils with 5 to 35% organics, compared with conventional test results. Comparisons very good, especially for corrected undrained shear strength using modified Marchetti correlation. (see Item 12E) The DMT p_c profiles correctly show an aging OCR effect in soft clays until recently considered NC. See item 12G.

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Lunne, T., Lacasse, S., and Rad, N.S. (1989) "SPT, CPT, Pressuremeter Testing and Recent Developments on In Situ Testing of Soils, PART I: All Tests except SPT", SOA paper prepared for Specialty Session at XII ICSMFE, Rio, 65 pp. Also in NGI No. 179, Oslo, 1990.

> All tests discussed, including DMT. Many correlations reviewed and expanded. DMT discussion includes a case history example of the successful prediction of lateral pile capacity using the method described by Gabr and Borden (1988). See Item 12H.

Marchetti, S. and Totani, G. (1989) "c_h Evaluations from DMTA Dissipation Curves", <u>Proceedings</u> XII ICSMFE, Vol. 1, pp. 281-286.

> Data from 3 Italian sites illustrating how the semilog inflection point in dissipation curves can be used for a qualitative evaluation of c_h , often sufficient for at least preliminary design decisions. Mentioned previously in DMT 11.K.2.

Mayne, P.W. (1989) Discussion, ASCE <u>Journal GED</u>, October, p. 1502.

Data showing good comparison between DMT OCR profile vs. from odometer and triaxial testing, in the moderately sensitive Norfolk-Yorktown clay formations (OCR = 4 to 9). Also CPTU profile data.

Mayne, P.W., and Bachus, R.C. (1989) Penetration Pore Pressures in Clay by CPTU, DMT, and SBP", <u>Proc.</u> XII ICSMFE, Vol. 1, p. 291.

> All the tests show a general relationship between effective preconsolidation stress and excess pore pressure as determined from each test. Intact and fissured clays show distinctly different trends.

NeJame, L. A. (1991) "Dilatometer Testing of the Marine Clay Deposit at Pease Air Force Base, New Hampshire". M.S. Thesis, Civil Engineering, Univ. of N.H., Sept., 364 pp. Sensitive silty clay site investigated in detail with DMT, SBPMT, vane and lab testing. Variety of field stress and pore pressure dissipation tests included. DMT did not measure increase in lateral stress at toe of large embankment.

Sully, J.P., and Campanella, R.G. (1989) "Correlation of Maximum Shear Modulus with DMT Test Results in Sand", <u>Proc. XII</u> ICSMFE, Vol. 1, p. 339.

> Research data suggests that E_D may provide reasonable estimates of small strain shear modulus G_D through empirical correlations. (note similar item in DMT 10.A.7)

Tanaka, A., Bauer, G. and Carvalho, J.B. Q-, (1989) "Failure and analysis of a concrete silo", <u>Proc</u>. XII ICSMFE, Vol. 1, p. 345.

> s_u depth profile from DMT, with $35 < s_u < 80$ kPa, showed excellent agreement with back-calculated values at failure. DMT showed best agreement vs. other insitu test methods. Crust involved. See Fig. 2 in paper.

<u>12B More Comparisons in sands between CPT q and q</u>:

DIGEST item 11.I previously noted the near-equivalency between q_c and q_d , at least in sands. If true, calculating q_d would provide important extra data from the DMT because it would open up the use of various engineering performance correlations that use q_c . We now have three more examples of good q_d/q_c comparisons:

- 1. In connection with routine testing of sand and clayey sands at a landfill site, the writer compared a q_d profile, using a surface load cell and the method described in Schmertmann (1982) for calculating q_d (routine in data reduction program), with a parallel (5 ft away) mechanical q_c profile. Figure 12B.1 shows the comparison, and they are, again, very similar.
- 2. Professor M. Jamiołkowski sent (late 1989) sent the editor some preliminary data from the continuing large-scale chamber testing of insitu devices going on in Milano, Italy. Among many other tests, they performed comparative DMT and CPT tests and compared q_d with q_c , using a load cell just above the DMT blade. They report that on the average the ratio $q_d/q_c = 1.2$

for two sands tested in their NC states, and = 1.1 for these same sands when overconsolidated.

3. Campanella (1991) reported that at one very well tested research site when $I_D>2$, then $q_d \simeq 1.1 q_c$ using electric CPT tips.

We now have a variety of data showing that $q_d \approx 1.1 q_c \pm 10\%$. This relationship can be used with confidence in sands, based mostly on electric CPT data. It may be used tentatively in all soils. As expected, $q_d > q_c$ because of the difference between the intermediate plane and axisymmetric deformations around the DMT vs. axisymmetric around the CPT.

<u>12C - Pressure Dissipation Tests -- A-B-C vs. A₂ vs. A</u>

The following refers to soils with a permeability low enough to require more than 1 minute to reach pressure equilibrium after DMT blade insertion. This means most soils with $I_0 < 2$.

For purposes of estimating such parameters as: 1) coefficient of consolidation, or 2) effective lateral stress against the blade, or 3) ambient pore water pressure, one can insert the blade and leave it in position and make a succession of readings vs. time until reaching an equilibrium or a recognizable point on the pressure dissipation curve. The question has been -- what method of dissipation to use for what purpose? Researchers have tried various methods, such as repeating the A-B-C sequence each time, performing the A-B-C (or $p_0-p_1-p_2$) sequence only once and thereafter repeating A only, or performing and repeating only the A readings. Please refer to these herein as the A-B-C, A_2 and A methods, respectively.

Concerning the A-B-C method, DIGEST item 11.K noted some problems with this method, especially sometimes reaching equilibrium at a pressure well below the ambient water pressure. NeJame (1991) reported some similar below-ambient equilibrium values after waiting for almost full dissipation in a silty clay. It appears that this method successively opens a 1 mm cavity which progressively takes longer to repressurize because of the decrease in surrounding hydraulic gradients into the cavity after each A-B-C cycle. In view of this evidence, this method seems unsuitable for present purposes and we recommend it not be used for dissipation tests.

The A_2 method opens the cavity with the first cycle, but one runs the risk of an unknown effective soil pressure gradually returning to act on the membrane. If the ambient water pressure is known, and the pressure dissipation appears to be reaching an equilibrium at or near this value, then one has evidence that the cavity has not closed completely. This is the best, possibly only method for using the DMT to measure u_0 in low-k soils. It also appears to be the best method, especially if the cavity remains open, for determining pore pressure dissipation and therefore c_h and permeability.

The A-method is the most appropriate for obtaining the equilibrium total stress, and effective stress if u_o can be estimated, against the penetrating blade. As Marchetti (1986) discussed, one can use this pressure, together with a friction coefficient to estimate pile friction. Marchetti and Totani (1989) also used the A-method to qualitatively estimate c_h .

12D - Soil Aging and Chamber Test Results:

L. Decourt (1989) pointed out in connection with the SPT that chamber tests appeared to require an aging factor (AF) correction before comparison with aged, insitu sands. He suggested AF \approx 2.0 for SPT N values. This is not a negligible factor, which has previously not been considered because it was not yet appreciated.

The Editor, (Schmertmann 1991) presented many examples from the laboratory and field, in sands and in clays, for modulus and for strength, of the approximate factor of 2 importance of aging. It appears that the direct application of correlations obtained from chamber tests may sometimes first require a correction for aging when applied to natural soils. For example, as discussed by Marchetti (1991) and Schmertmann (1991), the relative insensitivity of the DMT to OCR in chamber sands vs. field behavior (judging by good settlement predictions -- see <u>Figure 12A.1</u>) may result from aged natural sands vs. "baby" chamber sands. Past DMT DIGESTs have occasionally referred to chamber test results. They should be reviewed with this aging precaution in mind. Insights from comparative chamber testing, such as noted in 12C, may have to be modified by aging effects before application to similar soils in the field.

12E - Undrained Strength of Weak Clays:

One of the potentially practical and accurate uses for the DMT involves measuring the corrected* undrained strength, s_u , in soft clays. In such soils the blade insertion expands a cavity to the limit pressure, measured by p_o or p_1 , which depends on shear strength. As noted in the previous DIGEST item 11.L, this provides a theoretical basis for determining s_u from p_o or p_1 .

In the references noted under 12A.3, Larsson and Eskilson also compared the DMT-produced values of s_u with the correct field vane data typically used in Sweden. They developed their own correlation for

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corrected $s_{\rm u}$ from the DMT, based on limit pressure and cavity expansion theory -- generally similar to that presented in DIGEST Item 11.L, and they obtained

$$s_u = \underline{p}_1 - \underline{w}_2$$
, with F = 10.3 for inorganic clays (12.1)
F F = 9.0 for organic clays

<u>Figure 12E.1</u> shows the comparative DMT-s_u and other test profiles from the 9 sites investigated in these references. The authors commented on the excellent comparisons and considered eqn. 12.1 accurate to $\pm 10\%$. The writer found that eqn. 12.2 (Marchetti and Crapps, 1981) produces essentially the same results.

 $s_u = \frac{\sigma_v K_{D-}}{10} = \frac{p_o - k}{10}$ (12.2)

Note that it compares well, and conservatively, with the simplified $K_p/8$ formula noted in Figure 11.L.2, for corrected s_u/σ_v' .

Reference to the data bases presented in the previous parts (a), (b), and (c) of Fig. 11.1.2 will show that eqn. 12.2 defines an approx. lower bound for s_u and will therefore usually produce conservative s_u values over the whole range of s_u -- however, not always. NeJame (1991) reported average corrected/uncorrected vane s_u values of 19/33 kPa while eqns. 12.1 and 12.2 gave 35 and 32 kPa, respectively.

Convservatism is often necessary, but as discussed in 12G., the use of local correlations should permit more accuracy for OCR predictions. This also applies to s_u .

* With the common vane shear strength as the reference, after a correction for rate effects usually based on PI.

12F - Further simplified Ø' from the DMT

In Schmertmann (1982) the Editor presented a theoretical method for calculating the approximate plane strain peak friction angle from DMT data. But, it required a thrust measurement. However, making the thrust measurement often creates problems. Perhaps the insertion equipment cannot easily accommodate a load cell, or a load cell is not available, or the Engineer may be unwilling to make the assumption of negligible soil/rod friction above the friction reducer above the blade. Many researchers have placed a load cell immediately above the blade, but such cells are not readily available and they require calibration, extra wiring, and surface readout equipment. At the very least, thrust measurement adds expense. GPE, INC. Geotechnical Equipment—

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In an effort to avoid measuring thrust, Marchetti (1985) showed that q_c data, which was often available, could be used as an alternate to thrust measurement. <u>Figure 12F.1a</u> taken from Campanella and Robertson (1991) presents his method in graphical form. Because the Ø prediction is not sensitive to K_o, it may be estimated or known only approximately. <u>Figure 12F.1b</u> shows a comparison of the various methods at a UBC research site. They all appear to produce very good results when compared to values calculated from SBPMTs.

Since 1982, the Editor has thought that \emptyset' values predicted from the DMT are at least equal to, and probably superior to those obtained from sampling and lab testing. It now appears that Campanella's suggestion for using K_D has made the DMT more convenient to use for this purpose, though with a possible reduction in accuracy resulting from losing one independent measurement (the thrust).

12G - OCR in the 1 to 3 range

A conservative, accurate determination of the OCR profile from the DMT is most important in the low-OCR range where the design loading might exceed the preconsolidation plastic yield point. In the higher OCR range, say over 3, a large prediction error usually makes little practical difference.

Schmertmann (1991) showed that many, perhaps most or even all natural clays behave as if overconsolidated by aging effects. Before taking advantage of this effect the problem for an engineer is to demonstrate the OC by means of either insitu or laboratory tests. This has proven very difficult when using ordinary quality sampling and laboratory tests because of sample disturbance effects. The DMT offers an alternative. As Schmertmann (1991) demonstrated with a few examples, very high quality laboratory testing and/or the newer insitu tests such as the DMT have been able to demonstrate an aging overconsolidation. <u>Figure 12E.1</u> shows DMT examples taken from Larsson <u>et. al.</u> (1989) from 9 Swedish soft clays most or all of which were thought to be normally consolidated but are now known to have a useable preconsolidation effect.

Correlation information has now been accumulated by the Editor and others to show that one cannot expect an accurate, global correlation for OCR from the DMT. However, numerous site or region-specific correlations have proven surprisingly accurate -- for example 8 of the 9 cases in <u>Figure 12E.1</u> (right-most graphs). Everyone using the DMT has noted the striking resemblance between the K_p and the OCR profile. All the correlations use K_p. Larsson <u>et. al.</u> (1991) used OCR = $10^{0.16(KD-2.5)}$. All the others, including Marchetti's original, have used a power expression in the form of OCR = $c_1 K_p^{c^2}$. Almost all the correlation data

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in the OCR = 1 to 3 range falls between the Marchetti (1980) equation with $c_1 = 0.5$ and $c_2 = 1.56$, and the Lunne <u>et. al.</u> (1989) equation, based on the Powell and Uglow (1988) data, with $c_1 = 0.24$ and $c_2 = 1.32$.

Thus, for a globally conservative value for OCR in the range of 1 to 3 the Editor recommends the P and U equation OCR = 0.24 $K_{\rm D}^{1.32}$.

For more accurate estimates, at all OCR, one needs some site- or region-specific correlation data in the same soil. For such cases the Editor recommends using $c_2 = 1.5$ and using the correlation information to determine the best c_1 .

<u>12H - Pile lateral load p-y curves</u>

It appears that the DMT may have a special usefulness for predicting the lateral load deformation behavior of displacement piles. The DMT provides an approximate model for this problem, and indeed Marchetti originally intended it as a tool to provide soil parameters for lateral pile analysis. There are two methods that have been proposed, namely by Gabr and Borden (1988) and by Robertson <u>et. al.</u> (1989). Recently published research indicates that both methods provide very good results.

Lunne <u>et. al.</u> (1989) presented an example (p. 45, Fig. 90) showing excellent results using the B and G method on a research project in Norway. Marchetti <u>et. al.</u> (1991) also showed excellent results using the R method at a research site in Italy. Campanella and Sy (1991) showed the DMT gave the best predictions. These new examples are, of course, in addition to those initially offered by these authors to develop and support their respective methods.

It appears the DMT may become the test of choice for this problem. It has some important advantages over the PMT, notably less cost per test, a semi-continuous profile, and perhaps most importantly -- one can test close to the surface where most of the lateral pile deformation takes place.

<u>12I - DMT Suitability Tabulations</u>

Engineers sometimes find it useful to consult tabulations that indicate the relative accuracy and practicality of different types of insitu tests for different purposes, or their effectiveness in different soil conditions. Any such tabulations reflect the opinions, experience and expectations of their authors. Tables 12I.1 from Kulhawy & Mayne (1989) and 12I.2 by the Editor reflect their digested and extensive practical and research experience with the insitu tests involved.

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<u> 12J - Other "Dilatometers"</u>

Paul Mayne reminded the Editor that the world out there is full of "dilatometers". He sent the enclosed <u>Figure 12J.1</u> to make his point. Thus, if there is a chance for confusion, we need to identify our dilatometer by specifically calling it the "Marchetti dilatometer" or "Marchetti DMT".

<u>12K - List of Users</u>

The reader might be interested in who else has, and presumably uses, the Marchetti DMT equipment and who distributes it. The attached <u>Table 12K.1 and 12K.2</u> give our latest such compilations.

Very truly yours, John H. Schmertmann

John H. Sch Editor GPE, INC.

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LIST OF REFERENCES CITED AND NOT IN 12A

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Marchetti, S., Totani, G., Campanella, R.G., Robertson, P.K., and Taddei, B., (1986) "The DMT- σ_{hc} Method for Piles Driven in Clay", <u>Proceedings</u> of In Situ '86, ASCE Geotechnical Special Publication No. 6, Blacksburg, VA, June 23-25, pp. 765-779.

Marchetti, S., Totani, G., Calabrese, M., and Monaco, P. (1991) "P-y Curves from DMT Data for Piles Driven in Clay", Deep Foundation Instit. <u>Proc.</u> 4th Intnl. Conf. Deep Foundation Inst. on Piling and Deep Foundations, Stresa, Apr.

Powell, J.J.M. and Uglow, I.M. (1988) "Marchetti Dilatometer Testing In UK Soils", <u>Proc.</u>, ISOPT-1, Florida, Mar., Vol. 1, pp. 555-562.

Schmertmann & Crapps, Inc. (1988) "Guideline Summary for Using the CPT and Marchetti DMT for Geotechnical Design", Rept. No. FHWA-PA-87-014+84-24 submitted to PennDOT, Office of Research and Special Studies, Harrisburg, PA, Feb., in 4 volumes, Vol. GPE, INC.

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III - DMT Test Methods and Data Reduction (183 pp.)

Schmertmann, John H., (1982) "A method for determining the friction angle in sands from the Marchetti dilatometer test (DMT)", <u>Proc.</u>, 2nd European Symposium on Penetration Testing, Amsterdam, Vol. 2, May, p. 853.

Schmertmann, John H., (1991) "The Mechanical Aging of Soils", 25th Terzaghi Lecture, ASCE <u>JGE</u>, Vol. 117, No. 9, September, pp. 1288-1330.

Schmertmann, John H., (1991) Discussions to Leonards and Frost (1990), ASCE JGE Vol. 114, Jul 88, in Vol. 117, No. 1, pp. 172-188.





FIGURE 12A.1 (from Hayes, 1990)

FIGURE 12E.1 - COMPARATIVE REFERENCE DATA (•) WITH

DMT PREDICTIONS FROM 9 SWEDISH SITES IN

INORGANIC & ORGANIC SOFT CLAYS (Larsson, 1989)

p. 1 of 2







DILATONETERFORSOK: KUNSBACKA



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p. 2 of 2













substituting use of K_D for q_c (or thrust)

(a)

Proposed method

NOTE: ASSUMED CONE ROUGHNESS $\delta/\phi = 0.5$





(b) Prediction comparisons at one research site

FIGURE	12F.1
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SIMPLIFIED Ø' FROM THE DMT (from Campanella & Robertson, 1991)

MISTORICAL USE, MOBILIZATION AND ACCESS REQUIREMENTS, AND COSTS OF IN-SITU TESTS

Test	Historical Use	Availabilicy	Access	Unic Cost
SPT	Subscancial	Excellent	Truck, trailer	Medtum
ИСРТ	Subscancial	Good	Limited portability - truck, trailer	ν
ECPT	Moderate	Good	Limited porcability - truck, trailer	lov
CPTU	Limited	Poor	Limited portability - truck, trailer	Medium
VST	Substantial	Excellent	Limited portability - truck, trailer	Medium
DHT	Limiced	Fair	Limited portability - truck, trailer	ğ
TMT	Moderace	Good	Limited portability - truck, trailer	Medium
SBPHT	Liaiced	Poor	Limited portability - truck, trailer	High
Source:	Orchant, et a	1. (<u>3</u>), p. 2-62		

Test	COV ⁴ (I) Equipment	COV (Z) Procedure	Random	Total	
				COND (2)	_
	ETIMA	TES OF IN-SITU	TEST VARIABI	LITY	
		Table S	- 4		

ASSESSMENT OF IN-SITU TESTS Table F-1

Comparison Basis	Standard Penecracion Tesc	Cone Penetration Test	Vane Shear Teac	Pressure- Beter Test	Flac Dilacomecen Tesc
Simplicity of apparatue	Simple. rugged	Complex. Fugged	Simple. rugged	Complex, delicate	Simple, rugged
Ease of testing .	Easy	Easy	Easy	Complex	Easy
Concinuous profile or point values	Point	Concinuous	Poinc	Point	Semi-con-
basis for incer- precacion	Empirical	Empirical. theory	Theory	Empirical, theory	Semi-empiri cal, theory
Suitable soils	Hast types	Host types	Softer clays	Most types	Nost types
Suitability in practice	Routine	Routine	Routine	Linicad	Roucine

Table F-2

•		Soil Type						
_	gravel		sand		clay			
Test	<u>.</u>	loose	dense		soft	stiff		
SPT	2 to 3	1	1	2	3	3		
MCPT	2 to 3	1	2	1	1	2		
ECPT	3	1	2	1	1	2		
CPTU	3	1	2	1	1	2		
VST	4	4	4	3	1	2		
DMT	3	1	2	1	1	2		
m	2	2	1	1	1	1		
SBPMT	3	2	2	1	1	1		
Notes:	l - Highl 2 - Moder 3 - Limit 4 - Not a	y applicabl ately appli ad applicat applicable	HCPT ECPT CPTU SBPN	- Machan - Electr - Piezom I - Self-b	ical CPT ic CPT etric CPT oring PMT			

USEFULNESS OF IN-SITU TESTS IN COMMON SOIL CONDITIONS

Source: Orchant, et al. (3), p. 2-61.

Test	COV ⁴ (I) Equipment	COV (I) Procedure	COV (I) Random	COV ^b (I) Total	COV ^C (1) Range
Standard Penetration Test (SPT)	5 ^d to 75°	5 ^d to 75°	12 to 15	14 ^d to 100*	15 to 45
Mechanical Cone Penetration Test (MCPT)	5	10 ^f to 15\$	10 ^f to 155	15 ^f to 225	15 to 25
Electrical Cone Penetration Test (ECPT)	3	5	5 ^f to 108	7 ^f to 128	5 to 15
Vane Shear Test (VST)	5	8	10	14	10 to 20
Dilatometer Test (DMT)	5	5	8	11	5 to 15
Pressuremeter Test (PMT)	5	12	10	16	10 co 20 ²
Self-Boring Pressuremeter Test (SBPMT)	8	15	8	19	15 EG 25 ¹

Notes: a - COV - standard deviation/mean b - COV(Total) - [COV(Equipment)² + COV(Procedure)² + COV(Random)²]⁴ c - Because of limited data and the judgment involved in estimating COV values, ranges represent probable magnitudes of field test measurement error d - Best case scenario for SPT test conditions e - Worst case scenario for SPT test conditions f - Tip resistance CPT measurements g - Side resistance CPT measurements h - It is likely that results may differ for p₀, p_f, and p₁, but the data are insufficient to clarify this issue

insufficient to clarify this issue

Source: Orchant, et al. (3), p. 4-63.

- TABULATIONS FROM KULHAWY & MAYNE (1989) TABLE 12I.1

Table F-3

TABLE 12I.2 - From Schmertmann & Crapps (1988) SUITABILITY OF DMT IN DIFFERENT TYPES OF SOIL

Suitability Ranking:

0 = do not	use DMT	2 :	= good	
l = someti	mes suitable	3 :	= best	application

Note: Hammer-driving alters the DMT results and decreases the accuracy of correlations.

	SUITABILITY FOR DIFFERENT SOIL CONDITIONS					
	weak, NSPT<5,	loose * , q _c <15	medi NSPT=25	ium. 5,qc≖75	stiff, NSPT>44	dense**),q _c >150
SOIL TYPE	fills dumped, pumped	natural	fills light cmpxn.	natural	fills heavy cmpxn.	 natural
Clays	3	3	2	2	2	2
Silts	2	2	2	2	1	1
Sands	3	3	2	2	1	1
Gravel, lg. shell	I			1		
and concretions	1	1	0	10	0	I 0 I
Cobbles	0	0	0	0	0	0
Rock (weathered)	10	1	0	I 0	0	1 0 1
CL+SI+SD	3	1 3	3	2	2	2
CL+SI+SD+Shell	2	2	2	2	0	0
CL+SI+SD+Rock	1	1	1 **	1 **	0	0
Sand+Gravel	2	2	2 **	1 **	0	0
Organic CL+SD	3	3	12	2	1	1
Residual w/o rock	3	3	2	2	1	1
Residual w/ rock	1	i 1	0	1 **	0	0
Cemented sand	-	1	-	1 1 **	- 1	0
Tallus with rock	-	1	- 1	1 **	- 1	0
Glacial Till	0	1	10	1 0	10	1 0
Varved Clays	3	2	2	1 2	1	1
Loess	3	2	2	2	-	-
Peats	3*	2*	2	2	-	-
Slimes, tailings	3*	I –	2	-	-	-

* Sensitive testing in very weak soils.

** High risk of damage - use high strength blade & membrane.

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