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In situ and laboratory dissipation tests in estuarine and deep-seated saline soils

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ABSTRACT: Some standard in situ and laboratory dissipation tests (u_2, DMTA, oedometer compression) were evaluated by model fitting at the Szeged (saline) soft clay test site and at the Ballina (quick) soft clay test site, where destroyed structured soils are found in patches, representing a natural hazard. They provided the coefficient of consolidation *c*, coefficient of creep C_α. The saline-like and quick-like soils exhibited larger *c*, larger creep than soils normally. The *c* identified from the laboratory test was similar in both sites, but the in situ *c* was larger in Szeged than the laboratory value, due to the depositional conditions. In addition, some new, short (20 s long DMTA and q_c) dissipation tests were evaluated. By fitting a parametric power function, the result was two parameters and a point in the two-dimensional space. Linking with plasticity information, soil-profiling diagrams were resulted. The points on the diagrams had nearly coinciding regression line with slightly different plasticity scales for the two tests indicating nicely the damaged soils. The suggested model explains qualitatively the short test results, indicating dependence on the immediate stress drop (due to static-dynamic transition and structure destruction), in situ coefficient of consolidation *c* and coefficient of relaxation *s*.

KEYWORDS: Dissipation tests, coupled consolidation, CPT, DMT, oedometer.

1 INTRODUCTION

1.1 *Dissipation tests*

Various kinds of laboratory (Table 1) and in situ (Table 2) dissipation tests are available. Two-stage, laboratory oedometer tests are available. In the conventional compression staged (creep) test, stepwise total stress load is applied; in the oedometer multi-stage relaxation test, stepwise displacement load is applied in a partly drained manner (eg, at a constant rate of strain, ‘fast’). During the stages, the load remains constant, and the dual variables (displacement and total stress) are measured (along with the excess pore water pressure).

In CPT excess pore water pressure dissipation tests, dissipation is measured at the penetrometer surface ($r = r_0$). The filters can be in various positions (eg, u_1, u_2, u_3) on the penetrometer. The dissipation curve is either monotonic or non-monotonic, which is generally associated with low or high OCR values, respectively, but it also depends on filter position (Lim et al. 2019). The records are positive in the LOC clay and negative in the sand and can be partly negative on OC clay.

During a CPT piezo-lateral stress (PSL) cell test, both the radial total stress and the pore water pressure are measured, the former decreases by 73%, the radial effective stress decreases then increases with time in Boston Blue Clay (Baligh et al. 1985). (No similar measured data set is available in the case of granular matter.) The DMTA dissipation test is similar except that the total stress measurement is non-continuous (Appendix).

The 15 to 20-second-long CPT fs, q_c and DMTA dissipation tests are recorded in the break of penetration.

Table 1. Oedometric dissipation tests, stepwise load.

1	Symbol
(Multistage) relaxation test	(MRT)
(Multistage) compression test	(MCT)

Table 2. CPT in situ dissipation tests, boundary condition: forced displacement load of the penetrometer shape.

1	Symbol
Pore water pressure	CPT*u* and PSL
Total stress	DMT, CPT q_c PSL
Side friction	CPT f_s

1.2 *Test sites, aim of paper, source of data*

The aim of the paper is to identify quick and saline clay patches using the various dissipation tests. The sites and data sources were as follows. Concerning Szeged, the soil salinity was revealed in a part of the city, through statistical analyses and chemical laboratory tests ((Réthàti 1988; Imre 1995, 2014 to 2021). The u_2, q_c, and DMTA dissipation test data, the laboratory compression test data and the soil profile (Figure 1 (a)) is related to this part of the city, where the layers were normal clay; saline-like clay, granular soils (FTV, 2012, Marchetti, 2020). The saline groundwater is moving upwards, neglecting this, the soils are under-consolidated. The source of the salt is the over-pressured Pre-Neogene marine soils, the infiltrating freshwater may superimpose it.

Bishop (2009) mentioned first some largely compressible soils in Ballina estuaries, Australia. Within this layer, due to the post-depositional changes, the in-filtrating freshwater and river aquifers may have caused leaching, resulting in “quick clay” patches. The soil profile (Figure 1 (b) consist of quick-like clay, normal clay and granular soils close to the surface and between 12 and 16 m of depth. The characterization study carried out by the National Soft Soil Testing Facility (Pineda et al. 2016) offered the tests used here (compression test, DMTA and simultaneous u_2 and q_c dissipation tests). Moreover short DMTA test data were used from the Black In situ Testing expertise, made in December 2024 (Schofield, 2024).

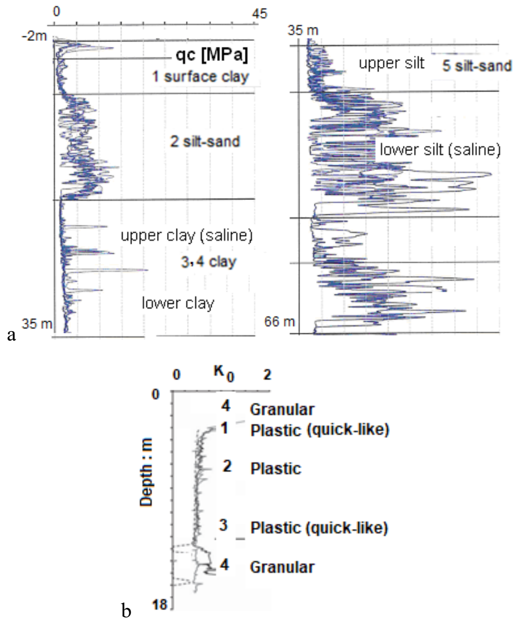

Figure 1. (a) Szeged, ELI, a q_c profile between 0 to 50m. 1 and 4: LOC normal clay, 3: LOC saline-like clay, 2 and 5: granular soil. (b) Ballina, K_0 porofile (SDMTAnd CPTu) 0 to 18m. 1 and 3: LOC quick-like clay, 2: LC normal clay, 4: granular soils.

To this end, the goal was to collect and compare mathematically precise and approximate, old and new evaluation methods.

2 LITERATURE REVIEW ON MODELLING

2.1 *Point-symmetric, coupled 1 and 2 consolidation models*

The point-symmetric, coupled consolidation models form "families" for the space dimensions $m = 1, 2$, and 3 with similar behavior and analytical solution (Imre et al. 2010). Concerning the two model families, the difference is only one boundary condition, as follows. The inner boundary r_0 ($m-1$ dimensional circle) is unmoved in both cases (for m=1 it is the oedometer top, $r_0 = 0$, for m=2 it is the CPT). The outer boundary at r_1 (for m=1 the oedometer base $H = r_1$. and for m=2 it is the zero excess pore water pressure line in the soils) differs. The suggested coupled 1 models uses K_0 (unmoved) boundary condition, the existing coupled 2 models use constant total stress (moving) boundary (Biot, 1941 and Randolph and Wroth 1979).

2.1.1 *The model solution*

Here, only the solutions relevant for this work are treated.The time variation the pore water pressure of the coupled 1 and 2, *cylindrical* models (m=2) is, resp.:

$$u(t,r)=\sum_{k=0}^{\infty}\gamma_k C_k e^{-\gamma_k^2 c_h t}\begin{Bmatrix}[I_0(\gamma_k r)+\mu_k Y_0(\gamma_k r)]\\ [I_0(\gamma_k r)+\mu_k Y_0(\gamma_k r)]\end{Bmatrix} \tag{1}$$

$$u(t,r)=\sum_{k=0}^{\infty}\gamma_k D_k e^{-\gamma_k^2 c_h t}[I_0(\gamma_k r)+\beta_k Y_0(\gamma_k r)] \tag{2}$$

where I_0 and Y_0 are Bessel functions of the first and second kind, λ_k, μ_k / γ_k, β_k are the roots of the boundary condition equations (depending on r_1 and r_0); C_k / D_k (k=1,2 . n) are the Bessel coefficients related to a given initial conditions, c_h (= $c = k\,E_{oed}/\gamma_v$) is coefficient of consolidation.

The transient part of the radial total stress at r_0 of the coupled 1 model is equal to the space mean of the excess pore water pressure on the displacement domain, between r_1 and r_0:

$$\sigma_r^t(t,r)\big|_{r=r_0}=u_{mean}(t) \tag{3}$$

Being the final value zero, the radial total stress at r_0 decreases/increases during consolidation by the absolute value of $u_{mean}(t=0)$ if it is positive/negative respectively. The transient part of the radial total stress at r_0 of the coupled 2 model is identically equal to zero, the radial total stress is constant during consolidation on the pile-soil interface.

The solution of oedometer relaxation test (coupled 1, m=1) model and of oedometer compression test (coupled 2, m=1) model for the displacement and the pore water pressure, resp.:

$$v^t(t,y)=\sum_{k=1}^{\infty}b_k\cdot\sin\left(\frac{k\pi}{H}y\right)e^{-\left(\frac{k\pi}{H}\right)^2 c\cdot t} \tag{4}$$

$$u(t,y)=\sum_{k=1}^{\infty}\alpha_k\left\{\left[\cos\left(\frac{k\cdot\pi}{H}y\right)\right]-1\right\}e^{\frac{k^2\cdot\pi^2}{H^2}c_v t} \tag{5}$$

$$v^t(t,y)=\sum_{k=1}^{\infty}b_k\cdot\cos\left[\frac{(2k-1)\cdot\pi}{2H}y\right]\cdot e^{-\left[\frac{(2k-1)\cdot\pi}{2H}\right]^2 ct} \tag{6}$$

$$u(t,y)=\sum_{k=1}^{\infty}b_k\cdot\frac{(2k-1)\cdot\pi}{2H}\cdot\sin\left[\frac{(2k-1)\cdot\pi}{2H}y\right]\cdot e^{-\left[\frac{(2k-1)\cdot\pi}{2H}\right]^2 ct} \tag{7}$$

where a_k and b_k (k=1,2 . n) are Fourier coefficients. The transient part of the radial total stress at r_0 =0 is equal to the space mean pore water pressure on the domain $u_{mean}(t)$, between $r_1 = H$ and $r_0 = 0$ for the coupled 1 model (Imre, 1995). The transient part of the radial total stress at r_0 =0 is identically equal to zero (Imre, 1995), the total stress load is constant for the coupled 2 model (which true in the cylindrical case, at r_0 too).

2.1.2 *The dimensionless variables*

Two dimensionless arguments are at m=1 for the coupled 1 and coupled 2 models (see Equation (3) to (6)):

$$R=\frac{r}{r_1-r_0}\quad\text{or}\quad R=\frac{r}{2(r_1-r_0)} \tag{8}$$

$$T=\frac{c\cdot t}{(r_1-r_0)^2}\quad\text{or}\quad T=\frac{c\cdot t}{4(r_1-r_0)^2} \tag{9}$$

The same dimensionless, approximate variables were derived from the boundary condition at m=2 and 3 (Imre et al. 2010) using asymptotic Bessel functions.

The solutions in terms of the normalised variables (at fixed normalized initial condition) for the various space dimensions (1, 2 and 3) are nearly the same in a model family, therefore, these can be interchanged (being useful since solution m=1 is simpler numerically than m=2, see Equations (1) and (4)).

2.2 *Time-dependent constitutive law*

The time-dependent constitutive law of the foregoing consolidation models is described by superimposing a relaxation or creep term at r_0 for the coupled 1 and 2 models, respectively.

In the joined 1 model, the coupled 1 model and, a relaxation term are superimposed at the boundary r_a:

$$\Delta\sigma_r(t,r)\big|_{r=r_0}=-s\,\sigma_r(0,r)\big|_{r=r_0}\frac{1}{1-s\cdot b}\log\left(\frac{t+t_1}{t_1+t_3}\right) \tag{10}$$

where s is the coefficient of relaxation, t_1 is the delay time, t_3 is the pause of relaxation, b=log[(t_1+t_3)/t_1] is a parameter causing delayed relaxation in case of partial unloading (due to the stress release of the CPT upon the stop of the steady penetration).

In the joined 2 model, the coupled 2 model and, a creep term are superimposed at the boundary r_0:

$$v^{cr}(t) = C_\alpha \frac{2H}{1+e_0} \log \frac{t+t_0}{t_0} \tag{11}$$

where C_α is the coefficient of creep, t_0 is the time parameter, e_0 is the initial void ratio, assuming a sample height of $2H$.

3 EVALUATION METHODS

3.1 *Least Squares, "precise" fitting of consolidation model*

A newly proposed LS fitting method was linked with the various model solutions (see, e.g., in Imre et al. 2024).

The u_2 dissipation test is evaluated with Equation (1) identifying c and the initial condition in two ways (using two software elaborated here). In the slow (I) method, the best-fit initial condition is selected out of 200 available shape functions for u_0; in the fast (II) method the coefficients C_i (i=1,2 . k) are identified (where k<5 due to numerical reasons).

In the DMTA dissipation test evaluation method M1, the simplest possible oedometer relaxation test model (without relaxation term) is fitted simultaneously on total stress and pore water pressure data - interchanging solutions m=1 and m=2 -, the c and the initial condition are identified. (First model fitting results indicated large parameter error without the pore water pressure data, which can be DMTC data, u_2 dissipation test data and can be generated using Equation (3), Imre et al. 2021).

The oedometric compression test data were evaluated by fitting the modified Bjerrum model (Bjerrum, 1967) with the software elaborated here, a coupled 2 consolidation model, adding an immediate compression h_0 term, and a creep term; the h_0, c and C_α were identified, then consolidation and creep settlements were computed.

3.2 *One-point fitting of consolidation model*

The long u_2 dissipation test evaluation with method III is based on the solution of the 2D uncoupled model of Teh and Houlsby (1988), which is fitted at the t_{50} point, the identified c:

$$c_{T-H} = \frac{T_{50}^{T-H}}{t_{50}} r_0^2 I_r^{1/2} \tag{12}$$

where r_0 is the radius of the rod, t_{50} is the measured time for 50% dissipation, I_r is the rigidity index, and $T^{T\text{-}H}$ is a time factor.

The DMTA Flex method is an empirical formula for c based on the t_{Flex} at the inflexion point (see eg., Monaco, 2021), results are shown in earlier papers and are referred here only.

3.3 *Empirical evaluation of short tests*

The short DMTA dissipation tests is evaluated such that an arbitrary power function is fitted on the measured A-pressure - t data (excel solver), providing R^2, b and a stress delta:

$$\sigma(t) = at^b \tag{13}$$

$$\Delta\sigma = \sigma(t_i) - \sigma(t_f) \tag{14}$$

where t = elapsed time, t_i = 0s or 1s and t_f = 15s or 20s. If the points with coordinate b and stress delta $\Delta\sigma$ are linked with soil type, soil profiling diagram is resulted (Imre et al. 2024). In here this method was newly applied to the q_c short test.

4 RESULTS

4.1 *Szeged*

The layers appeared distinctly in the long u2 dissipation curves (Figures 1, 2, Table 3). The dissipation curves were non-monotonic, shorter for saline-like soils and negative in sands. The fast method II – as usually – gave highest c (Imre et al. 2024). The compression test results are shown in (Table 4). The c, and C_α were larger for saline-like than for normal clay. The creep settlement was 72% or 51%, consolidation settlement was 23% or 51% for the saline-like or normal clays, respectively.

The distance between CPTu and DMTA test sites was 35m. Despite of this, somewhat unexpectedly, the short q_c and DMTA saw-tooth-like short test records (see also the Appendix), after evaluation, provided similar diagram points (Tables 5 and 6; Figure 3). There were very similar linear regression lines on the evaluated test points.

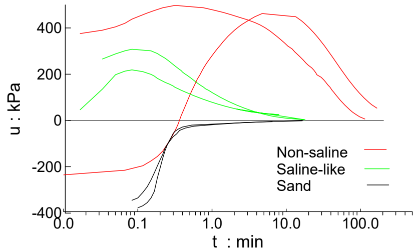

Figure 2. Szeged, ELI, u_2 excess pore water pressure dissipation curves in sand-silt (negative, 40m, 50m), in normally or lightly over-consolidated clays (saline-like clay in 21m, normal clay in 24m.

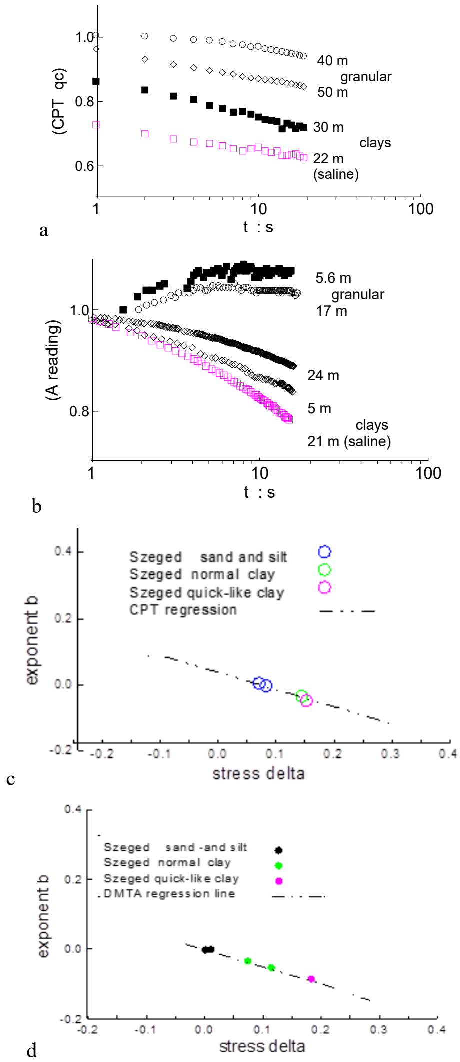

Figure 3. Szeged, ELI, short q_c and DMTA dissipation test. (a, b) Test records (pink: saline). (c, d) The diagram points with soil type information were similar. The linear regression lines and the soil plasticity scaling were also similar.

Table 3. Szeged, ELI, u_2 and DMTA dissipation test, c: m^2/s

Method	DMTA M1	I slow	II fast	III t_{50}
sand		4.00E-03	6.00E-03	
saline clay	5.00E-05	5.00E-05	3.00E-04	5.00E-05
clay	1.00E-05	1.00E-05	1.00E-05	2.00E-06
silt		2.00E-03	2.00E-03	

Table 4. Szeged, ELI, oedometer test, clays

name (boring/depth: m /load: kPa)	Non-saline clay 103/27/300)	Saline clay (103/21/200)
c: m^2/s	9.00E-09	4.00E-08
$E_{oed}{}^*$: MPa	11.98	6.61
E_{oed}**: MPa	17.4	30
h_0: mm	2.04E-02	2.04E-02
C_α	5.26E-02	5.26E-02
immediate/creep/primary	0.03/0.51/0.46	0.05/0.72/0.23
Load: kPa/max settl.: mm	500/0.08	400/0.11

* E_{oed} at the in situ effective stress, ** E_{oed} without creep settlement.

Table 5. Szeged, ELI, evaluation of short D dissipation tests, granular: blue (positive b, large R^2), saline-like: red, normal clay: black.

depth m	delta, $\Delta\sigma$	exponent, b	R^2
5	0.121425	-0.057	0.9889
11	0.006575	0.0028	0.247
17	-0.00392	0.0017	0.3424
21	0.197288	-0.094	0.9688
24	0.076569	-0.035	0.8429

Table 6. Szeged, ELI, evaluation of short q_c dissipation tests, granular: blue (positive b, large R^2), saline-like: red, normal clay: black.

depth m	delta, $\Delta\sigma$	exponent, b	R^2
50	0.093957	-0.035	0.9657
30	0.151717	-0.064	0.9878
40	0.082567	-0.028	0.9102
22	0.159094	-0.077	0.9079

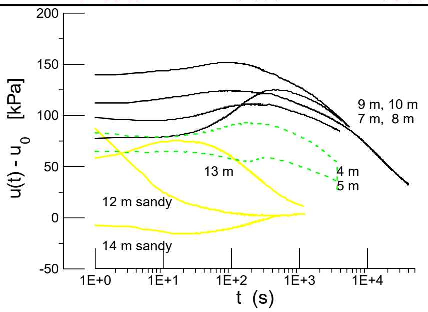

Figure 4. Ballina, long u_2 dissipation test records. Quick-like clay: 13m, silty-sandy: 1.6m, 12m and 14m, small permeability clay: 7m to 10m, larger permeability clay: 4 to 5m, which is slightly different in the DMTA and CPT q_c tests.

4.2 *Ballina*

The Ballina profile (Figure 1) includes upper and lower quick-like clays and granular soils moreover, normal clays. The long u_2 dissipation tests were non-monotonic and negative in sands. The c was larger, the t_{50} dissipation time was shorter in the quick-like clays than in normal clays (Figure 4, Table 7).

Evaluating two stages of the "Inclo 2" boring oedometer tests (Table 8), 38%/32% creep and 72%/78% consolidation ratio was found in the 2.8m quick-like / 6.7m normal clay, resp.

Evaluating short CPT q_c and DMTA dissipation tests, the picture was very similar to the case of Szeged. The sand-silt, clay, and quick-like clays appeared consecutively on the similar regression lines of the soil profiling diagrams (Figure 5, Tables 9, 10). The plasticity scaling showed a shift for the two kinds of tests again. The clay at 4 to 5m in these differed (partly due to the test distance of 18m, partly due to the immediate stress drop (missing for DMTA); it was saline for the q_c dissipation tests only.

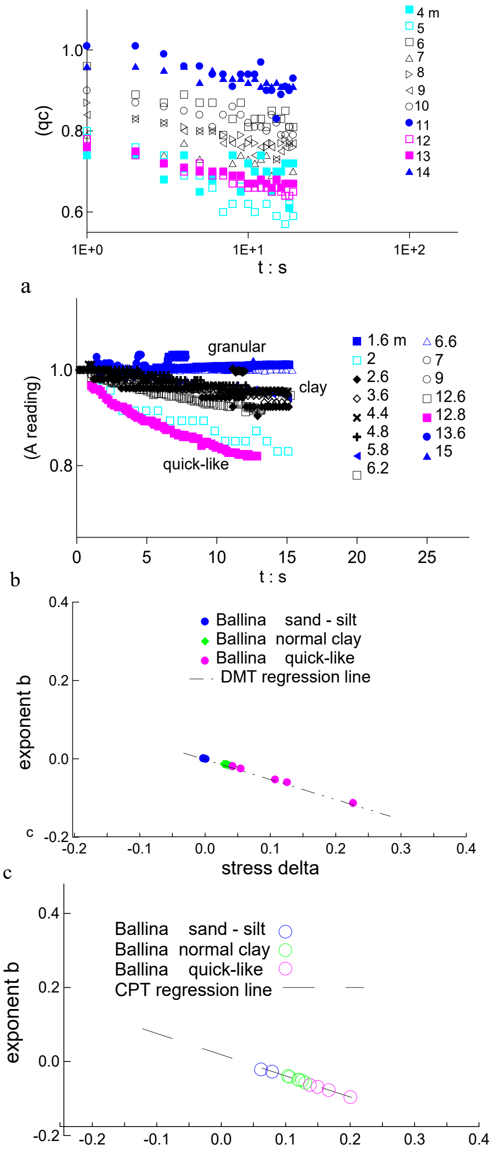

Figure 5. Ballina, short q_c and DMTA dissipation test. (a, b) Measured records (light blue and pink: saline, dark blue: sand, black: normal clay). (c, d) DMTA and CPT q_c diagrams with soil type and regression lines.

5 DISCUSSION

5.1 *Oedometer compression test results*

The identified c was similar at both sites (Tables 4 and 8). The compressibility was larger (and the permeability smaller) for Ballina than for Szeged clays (see Figure 6). The primary consolidation was dominant for loads above the′ yield stress in Ballina. The reverse was true for the Szeged clay, which had larger creep settlement than consolidation settlement.

5.2 *The short DMTA dissipation tests*

The DMTA short dissipation test records showed time-dependent A-pressure decrease/increase in clays/sands in a saw-tooth-like manner, with an increasing scatter as plasticity decreased (Figures 3, 5).

The stress redistribution in the equipment - soil system resulted in saw-tooth-like records with large R^2 in sand where residual stresses are huge (Poulos, 1987; Prodinger 1984). The modelled total stress decreases/increases by the absolute value of the initial, mean excess pore water pressure (Equation (3)), which was positive / negative for clays and sands (see Figures 2 and 4, and Kouretzis et al. 2014), respectively, verifying the coupled 1 consolidation model. The increase in total stress (A pressure) during dissipation is reported obstacle to penetration in sand in several cases (Schnaid et al. 2016; Chen Yang 1956).

The soil plasticity scaling on the diagram depended on the model variables (in situ coefficient of consolidation *c* and relaxation *s*), which were also dependent on soil type. Different in situ *c* values yielded different stress-delta parameters for the Ballina and Szeged clays here and across all other sites (see Figure 7 and Table 9).

Concerning the similarity with the short q_c test, it can be noted that the immediate stress drop, due to the dynamic-static transition, is not apparent in the DMTA dissipation test due to the non - continuous DMTA - reading (Appendix). The short q_c and DMTA dissipation test diagram linear regression lines and scaling were similar here. The only difference was the clay at 4 to 5m in Ballina, which differed partly due to the test distance of 18m, partly due to the immediate stress drop (missing for DMTA); it was saline for the q_c dissipation tests only. The similarity is probably partly since side and tip forces are not independent.

5.3 *The long DMTA and u_2 tests*

The results of the various methods (Figure 8) showed the same pattern as in Szeged site, the fast method II gave higher *c* than the remainder methods, in soft clay. It can be noted that the methods available may give unrealistic results in case of partly drained penetration (eg., if $t_{50} < 120$s, if starting from less than u_0 values see Robertson et al. (1986), if $t < t_{50}$. or if there is no inflexion point).

Table 7. Ballina - long u_2 and DMTA dissipation test, *c*: m²/s (red: quick–like soil, blue: granular 4, black: normal clay).

Method	DMTA M1	I slow	II fast	III t_{50}
4 m		3.00E-06	5.00E-06	1.90E-07
5m		5.00E-07	2.00E-06	4.00E-08
6 m			3.00E-06	7.00E-08
7 m	7.00E-08	5.00E-08	7.00E-07	7.00E-08
8 m			5.00E-06	9.50E-08
9 m		2.00E-06	2.00E-06	1.00E-07
10 m		7.00E-08	3.00E-06	1.00E-07
11 m		9.00E-07	9.00E-05	1.00E-07
12 m		4.00E-04	2.00E-03	2.10E-04
13 m		9.00E-07	8.00E-05	4.00E-06
14 m			1.00E-04	2.20E-03

Table 8. Ballina, Inclo 2 oedometer test, evaluation of two stages

depth: m / load: kPa	2.8 / 214	6.7 / 216
c: m²/s	9.00E-09	2.00E-08
Eoed*: MPa	1.40*	1.30*
Eoed**: MPa	3.40	2.50
h_0: mm	0	0
C_α	0.025	0.032
immediate/creep/primary	0/0.38/0.62	0/0.32/0.68
Load kPa/vol. strain	214/0.23	216/0.28

* E_{oed} at the in situ effective stress, ** E_{oed} without creep settlement.

6 SUMMARY, CONCLUSION

The result of the evaluation of the conventional, staged oedometer tests with the modified Bjerrum model was the coefficient of consolidation *c,* the coefficient of creep C_α and from these, the ratio of creep settlement to total settlement.

The *c,* C_α and the computed ratio were larger for altered soils in both sites. The *c* for normal clays was similar at both sites; however, the compressibility was higher (Figure 6) and the permeability smaller for Ballina than for Szeged clays. The in situ (u_2) *c* and laboratory *c* were similar in Ballina and different in Szeged, due to different depositional conditions.

Evaluating the long u_2 and DMTA dissipation tests with the various methods, the identified *c* had a similar pattern at both sites (Figure 8). Not apparent here but the suggested methods have the advantage that they are valid after partly drained penetration (being the initial condition identified) and if $t < t_{50}$.

The result of the short DMTA total stress dissipation tests were explained by the suggested joined 1 model family (coupled 1 consolidation part-model super-imposed with a relaxation part model), as follows. (The coupled 2 model family results no total stress change at the boundary). The relaxation may cause some additional total stress decrease.

The short DMTA dissipation tests showed time-dependent total stress decrease / increase in clays / in sands, due to the positive and negative initial excess pore-water pressure distributions, resp. The plasticity spacing in the diagram for normal clays was dependent on in situ *c* (Figure 7).

The saline and quick-like soils had larger stress delta parameters being the *c* and *s* higher. The immediate stress drop, due to the dynamic-static transition and the elastic response of soil texture, was important information in identifying the altered soils. The short q_c test had immediate stress drop, but it was not apparent in the DMTA dissipation test due to the measuring technique (see the Appendix).

Although the short q_c test has different model interpretation due to the different boundary condition below the tip, it resulted unexpectedly similar diagrams and regression lines, possibly since side and tip forces are interdependent. Earlier, the q_c and f_s tests, with other functions yielded soil profiling diagrams in Szeged /Debrecen sites (Imre et al. 2024).

Table 9. Short DMTA short dissipation tests evaluation, rounded Ballina values (red: quick-like clay, blue: granular, black: normal clay).

depth: m	delta, $\Delta\sigma$	exponent, *b*	R^2
1.6	0.23	-0.11	0.91
2	0.13	-0.06	0.92
2.6	0.04	-0.02	0.74
4.4	0.04	-0.02	0.85
4.8	0.03	-0.02	0.69
5.8	0.04	-0.02	0.81
6.2	0.03	-0.01	0.91
7	0.04	-0.02	0.88
8.2	0.03	-0.01	0.82
9	0.03	-0.01	0.82
12.6	0.05	-0.03	0.83
12.8	0.11	-0.05	0.85
13.2	0.003	0.001	0.26
15	0.002	0.001	0.26

Table 10. Short q_c short dissipation tests evaluation, rounded Ballina values (legend in Table 10).

depth: m	delta, $\Delta\sigma$	exponent, *b*	R^2
4	0.14	-0.06	0.65
5	0.20	-0.10	0.87
6	0.10	-0.04	0.79
7	0.13	-0.06	0.80
8	0.13	-0.05	0.92
9	0.12	-0.05	0.91
10	0.11	-0.04	0.90
11	0.08	-0.03	0.49
12	0.17	-0.08	0.97
13	0.15	-0.07	0.92
14	0.06	-0.02	0.81

Table 11. Ballina and Szeged clay and silt, typical (mean) values

	in situ c: m²/s	delta, $\Delta\sigma$	exponent, *b*	R^2
Ballina clay	1.4E-06	3.4E-02	-1.5E-02	8.4E-01
Ballina sand	1.0E-03	2.5E-03	1.0E-03	2.6E-01
Szeged clay	8.0E-06	7.7E-02	-3.5E-02	8.4E-01
Szeged sand	5.0E-03	1.3E-03	2.3E-03	2.9E-01

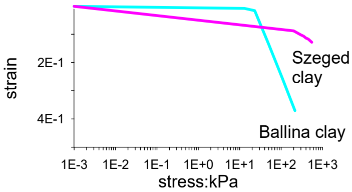

Figure 6. Comparing compression curves in Szeged and Ballina.

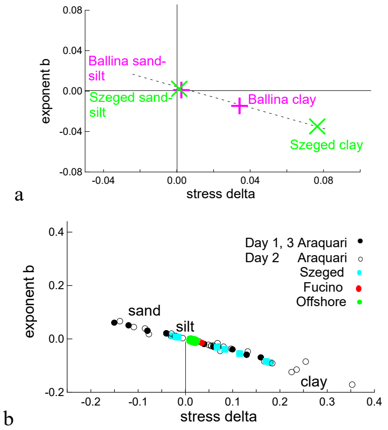

Figure 7. Short DMTA dissipation test results. (a) Mean values, Szeged and Ballina (see *c* in Table 9). (b) 4 sites, common diagram.

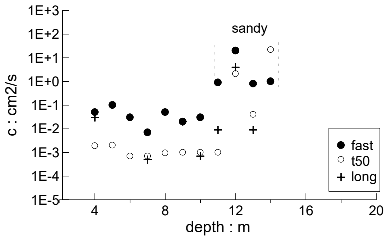

Figure 8. . Comparing results of three u_2 evaluation methods, Ballina

In conclusion, the short DMTA and q_c total stress dissipation tests (reflecting interdependence) yielded some very similar soil profiling diagrams with similar additional information on altered, destroyed soil structure in soft clay and granular soils within 20 s, using the suggested empirical evaluation method.

The oedometer tests evaluated by the modified Bjerrum model, resulting c and C_α (with ratio of creep to total settlements); moreover the c identified from u_2 test gave similar results on bad textured soils as the short tests but in longer time.

The suggested consolidation model with time dependent constitutive law (i.e., the sum of a linear consolidation and relaxation) explained qualitatively the short DMTA total stress dissipation test results and the diagram points.

In future research, the OC soil's behaviour in the short tests and, the possibility of the mathematically precise evaluation of the long total stress dissipation tests will be analyzed.

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9 APPENDIX 1: THE DMTA – READING, PROFILES

Once the blade is advanced to the test depth, the horizontal pressure of the soil flattens the membrane against the sensing disc, and the contact is active. When the internal pressure counterbalances the external soil pressure, the membrane starts to expand horizontally, losing electrical contact. In this instant, the lift-off pressure is defined as A-pressure (Monaco, 2021).