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Comparing Water Contents of Organic Soil Determined on the Basis of Different Oven-Drying Temperatures

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Water content determination using oven-drying method

$$\text{Water content, } w = \frac{m_w}{m_d} \quad (1)$$

m_d , specimen equilibrium dry mass (dry solids mass)

m_w , mass of pore water (mass of wet specimen – dry solids mass)

For mineral soils, with a few exceptions, employ standard oven-drying temperature (t) ranges of:

105–110°C (BS 1377-2)

110 ± 5°C (ASTM D2216)

For organic soils:

Oven-drying for $t > 80\text{--}85^\circ\text{C}$ may cause some charring and/or oxidation of susceptible organic matter

=> Reduction in specimen equilibrium dry mass, Δm_d : perceived as increase in mass of pore water

⇒ Over-prediction of water content value, that is:

$$w_{\text{high}} = \frac{m_w + \Delta m_d}{m_d - \Delta m_d} \quad (2)$$

For $t < 100^\circ\text{C}$, all pore water is not evaporated

=> under-prediction of water content value occurs for $t < 85^\circ\text{C}$ (approximately) (O'Kelly, 2004, 2005b)

Reduction in specimen equilibrium dry mass for increasing t value significant for peat and other highly organic soils

Figure 1.

All data reproduced from O'Kelly (2005a)

Label	Soil type	Liquid limit (%)	Plastic limit (%)	Particle density (Mg/m ³)	Loss on ignition, N (%)
1	Silt	65	32	2.66	3.0
2	Clay	83	35	2.70	5.6
3	Marl-1	116	95	2.22	6.7
4	Marl-2	131	106	2.41	6.9
5	Shelly marl	107	59	2.35	10.0
6	Organic marl	180	130	2.06	29.7
7	Organic clay	315	53	1.55	70.0
8	Peat-1 [H3]	900	310	1.19	87.7
9	Peat-2 [H4]	735	485	1.47	92.9

Impact of adopting different t values

- *For instance, in correlating undrained shear strength with water content*

Figure 2. Undrained strength correlations for water-treatment residue material ($N = 57\%$) (O'Kelly, 2014).

- *Also effects values computed from mass – volume relationships.*

As concluded in the papers by O'Kelly (2014), O'Kelly and Sivakumar (2014) and Skempton and Petley (1970):

the standard t value of 105°C employed for inorganic soil is appropriate and preferable than using lower t values in performing routine water content determinations on peat and other organic soils.

Figure 3 shows sample data demonstrating drying behaviour of Clara Bog peat material in gravity–convection oven for step increases in t value (O’Kelly and Sivakumar, 2014)

Material property	Clara peat
Water content (%)	1065
Liquid limit (%)	757
Plastic limit (%)	446
Plasticity index	311
Particle density (Mg/m ³)	1.42
Fiber content (%)	16.7
Loss on ignition, N (%)	98.5
pH	3.7

Reduction in specimen dry mass against drying period for different t values

For consistency, *recommended that values of water content corresponding to standardised t value of 105°C are deduced in cases where measured or reported water content values have been determined on the basis of lower t values* (O’Kelly, 2014; O’Kelly and Sivakumar, 2014).

According to the method after O’Kelly (2004, 2005a), **the water content value corresponding to $t = 105^{\circ}\text{C}$ (i.e., $w_{105^{\circ}\text{C}}$) can be computed from the water content value deduced for $t^{\circ}\text{C}$ (i.e., $w_{t^{\circ}\text{C}}$) according to the following expression:**

$$w_{105^{\circ}\text{C}} = (w_{t^{\circ}\text{C}} - \alpha_{105^{\circ}\text{C}} + 1) / \alpha_{105^{\circ}\text{C}} \quad (3)$$

where $w_{105^{\circ}\text{C}}$ and $w_{t^{\circ}\text{C}}$ are expressed in dimensionless form (not % values)

and the **water content parameter**, $\alpha_{105^{\circ}\text{C}} = m_{105^{\circ}\text{C}} / m_{t^{\circ}\text{C}} \quad (4)$
[$\alpha_{105^{\circ}\text{C}} \leq 1$ for $t < 105^{\circ}\text{C}$]

where $m_{105^{\circ}\text{C}}$ and $m_{t^{\circ}\text{C}}$ are the specimen equilibrium dry masses corresponding to t values of 105°C and $t^{\circ}\text{C}$, respectively.

Determination of pertinent $\alpha_{105^{\circ}\text{C}}$ value

- *Experimentally derived*

Figure 4. $\alpha_{105^{\circ}\text{C}}$ values plotted against drying temperature for Clara Bog peat material (O'Kelly and Sivakumar, 2014)

However, soil specific and time consuming exercise

- *Correlation*

O'Kelly and Sivakumar (2014) investigated the relationship between N and the gradient of the $\alpha_{105^{\circ}\text{C}} - t$ trend-line for 18 very different organic soils.

O'Kelly and Sivakumar (2014) denoted the gradient of the best-fit line to the $\alpha_{105^{\circ}\text{C}} - t$ plot for $t \leq 105^{\circ}\text{C}$ as the $\beta_{105^{\circ}\text{C}}$ parameter value, which they presented as a function of the N value, as shown in below figure.

Deduced relationship given by

$$\beta_{105^{\circ}\text{C}} = 0.00026 \times \ln(N) - 0.00023 \quad (5)$$

($n = 22$)

Included in this figure are additional data from forthcoming article entitled '*Water Content Determinations for Peaty Soil Using the Oven-Drying Method*' by Weichao Li *et al.* for four highly decomposed peaty soils ($N = 32.5\text{--}73.4\%$) sampled from the northeast shore of Dianchi Lake in Kunming city, Yunnan, China.

Summary and Conclusions

Growing consensus is that standardised t value of 105°C used for inorganic soil is also appropriate for routine water content determinations on organic soils.

Method for computing and comparing water content values determined for different t values presented.

$\beta_{105^{\circ}\text{C}}$ value estimated for a specific organic soil from its measured or reported N value using correlation given by Equation 5.

Pertinent $\alpha_{105^{\circ}\text{C}}$ value used for making comparisons and standardisation of water content values determined on the basis of different t values estimated from deduced $\beta_{105^{\circ}\text{C}}$ value and the difference in the t values employed.

In other words, water content values determined for $t < 105^{\circ}\text{C}$ standardised to the recommended t value of 105°C using the estimated $\alpha_{105^{\circ}\text{C}}$ value and Equation 4.

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