An Automated System for the Quasi-Continuous Measurement of the Particle-Size Distribution

Attila NEMES[1], Imre CZINKOTA[2], György CZINKOTA[3], László TOLNER[2] and Balázs KOVÁCS[4]

[1] ALTERRA Green World Research P.O. Box 47 Droevendaalsesteeg 3.6700 AA, Wageningen, The Netherlands
[2] Szent István University, Dept. of Soil Science and Agricultural Chemistry,Páter Károly u. 1., H-2103 Gödöllő, Hungary
[3] ALTAIR Bt. Hegyalja u. 13, H-2151 Fót, Hungary
[4] University of Miskolc, Dept. of Hydrogeology and Engineering Geology,H-3515 Miskolc-Egyetemváros, Hungary

Introduction

Soil texture is an important parameter for many soil and land related studies, among others for soil hydraulic pedotransfer functions (PTFs). Common soil particle-size classes are required to be able to uniformly determine the texture of the soils. However, it is not always possible – due to different national classification systems (see Figure) – and much valuable information is disregarded while either deriving or applying PTFs.

One way to get common particle-size information is to interpolate the particle-size distribution (PSD) curve. Advanced interpolation solutions are becoming available, but there is always uncertainty associated with these techniques. Another possibility is to measure all PSD curves in such a way that it is compatible to more of the commonly used classification systems.

A new automated measurement technique is introduced, that can easily provide PSD data compatible to any (and all) of the existing national and international classification systems at the same time. A computerized measurement system has been developed to record density changes in a settling-tube system in arbitrarily small time steps. This in turn allows the derivation of a quasi-continuous PSD curve. The measurement is based on *areometry* (Stokes-law), thus the system is compatible to the most commonly applied settling-tube type measurement systems.

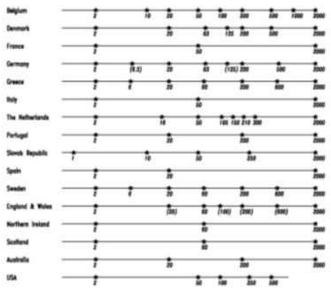
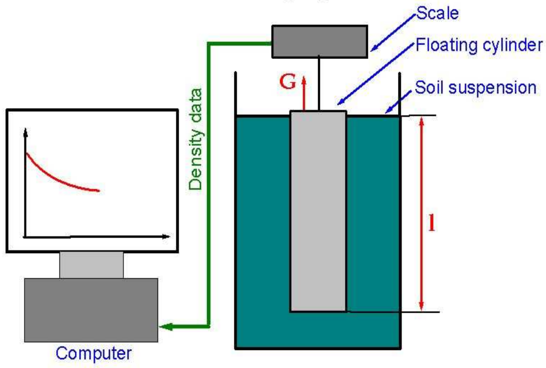
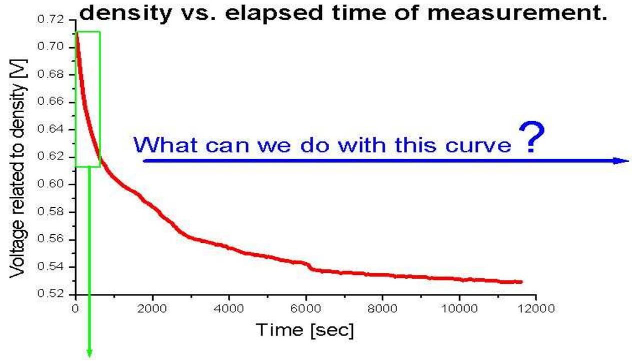


Figure: Particle-size limits (μm) used in some European countries, Australia and the USA

Scheme of equipment



Example of an original measured curve of density vs. elapsed time of measurement.



Physical model

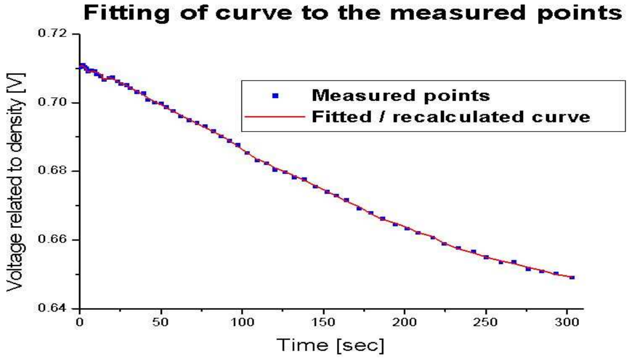
$$\Delta G = \frac{1}{2} \cdot A \cdot g \cdot (\rho_p - \rho_w) \cdot \sum_{i=1}^{n} \{c_i \cdot [abs(l - v_i \cdot t) + (l - v_i \cdot t)]\}$$

A	cross-section of floating cylinder, m	l	height of floating cylinder, m
g	gravity acceleration, 9.81 m.s^{-2}	ΔG	change of weight, kg.m.s^{-2}
ρ_p	density of suspended particles, kg.m^{-3}	ρ_w	density of liquid, kg.m^{-3}
c_i	concentration of suspended particles, kg/kg	v_i	deposition speed of ith fraction m.s^{-2}
t	time, s	n	number of fractions

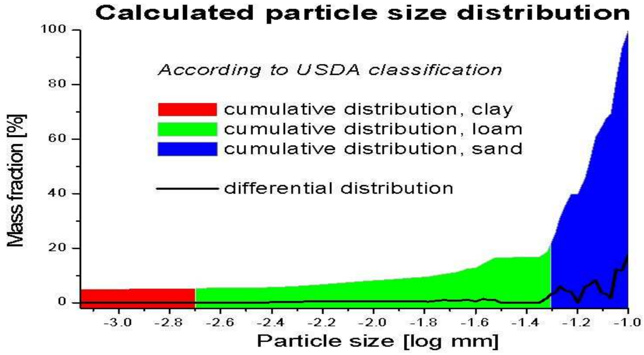
Calculation method

Multiple linear regression is performed in each required particle-size range. Particle-size distribution can be calculated from the normalized integral concentration of every particle size fraction.

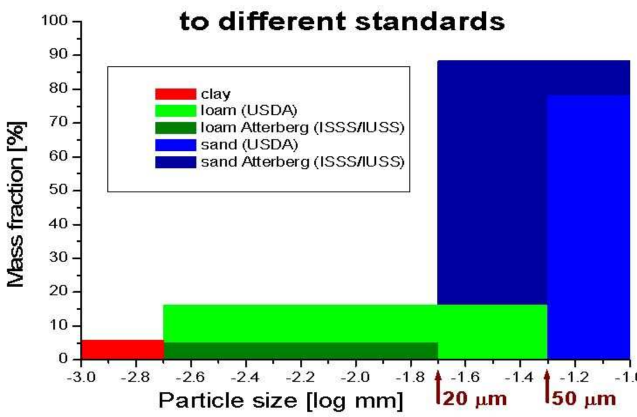
Fitting of curve to the measured points



Calculated particle size distribution



Particle size distribution converted to different standards



Features

- The new evaluation method of measured values takes the density changes along the areometer–body into consideration, so it avoids the problem of reference point determination.
- Initial comparative measurements show excellent correspondence with conventional settling-tube results for various soil materials.
- Reproducibility of the measurement shows to be very high.
- Using this technique does not require more sample preparation than past methods.
- The automated reading requires less manpower to perform the measurement, which reduces risks of human errors.
- It reveals multi-modality and fine-scale details of particle-size distribution.

Conclusion

- The presented particle-size measurement system makes the unification of soil texture description possible while keeping compatibility with the systems commonly used nationally and internationally. The provided quasi-continuous particle-size distribution curve could be useful as standard for the description of PSD. Using such a curve, current limitations in soil texture comparisons could be overcome, errors associated with particle-size interpolations could be disregarded. Background for further international co-operation may be improved, advancing the creation of further international databases and maps, and allowing the deduction of more reliable conclusions than currently possible.