The use of a High-Capacity Tensiometer for Determining the Soil Water Retention Curve

Discussion by

Claudio Fernando Mahler, Ronaldo Luiz dos Santos Izzo

The technical note presented by the authors is interesting. The use of high-capacity tensiometers has been reported for some time by other authors as well, such as Ridley & Burland (1993), cited in the note, and others, like Mahler *et al.* (2002), who presented a tensiometer made of acrylic and using another type of transducer (see Figs. 1, 2 and 3) that is much cheaper than the Entran transducers used by Ridley & Burland (1993) and the authors. If fact, Mahler *et al.* (2002) already proposed the use of high-capacity tensiometers together with TDR probes to determine soil moisture to obtain characteristic curves. One of these is presented in Fig. 4, obtained in soils used in a mini-lysimeter that was collected near Rio de Janeiro from gently rolling terrain. It can be characterised as sandy soil and the grain size curve is given in Fig. 5. This mini-lysimeter is depicted in Figs. 6 and 7. The description of the soil preparation and subsequent placement in the pot can be seen in Mahler *et al.* (2001). The initial saturation water content was approximately 20%, very near to field capacity. The results of the tensiometer presented here were compared to those of other devices also installed in a mini-lysimeter at the same depth as the equitensiometer (Fig. 8). More information on the equipment utilized in this study can be seen in Mahler *et al.* (2002). Figure 9 shows the results obtained with the then-new tensiometer and equitensiometer.

The main final remarks so far are as follows:

• The high bubbling pressure of the ceramic stone inhibits the presence of air bubbles, but the response is slower for suction values greater than 200 kPa;

• The saturation process used for the ceramic stone, which can be seen in Mahler *et al.* (2002) and Pacheco (2001), worked very well;

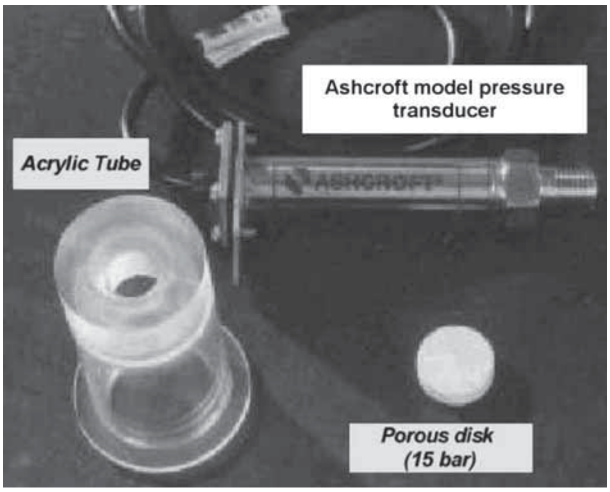

Figure 1 - Components of the new instrument (Pacheco, 2001 and Mahler *et al.*, 2002).

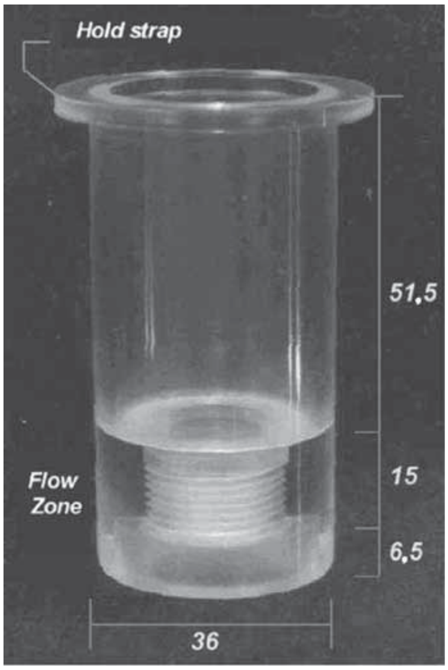

Figure 2 - Acrylic tube dimensions in milimiters (Pacheco, 2001 and Mahler *et al.*, 2002).

Claudio Fernando Mahler, LD, D.Sc., Professor, COPPE/UFRJ, Rio de Janeiro, R.J., Brazil. e-mail: mahler0503@yahoo.com.
Ronaldo Luiz dos Santos Izzo, D.Sc., Doutor, COPPE/UFRJ, Rio de Janeiro, R.J. Brazil. e-mail: ronaldoizzo@gmail.com.
The use of a High-Capacity Tensiometer for Determining the Soil Water Retention Curve by Marinho & Teixeira. Published in Soils and Rocks v. 32(2), p. 91.
Received and accepted on .

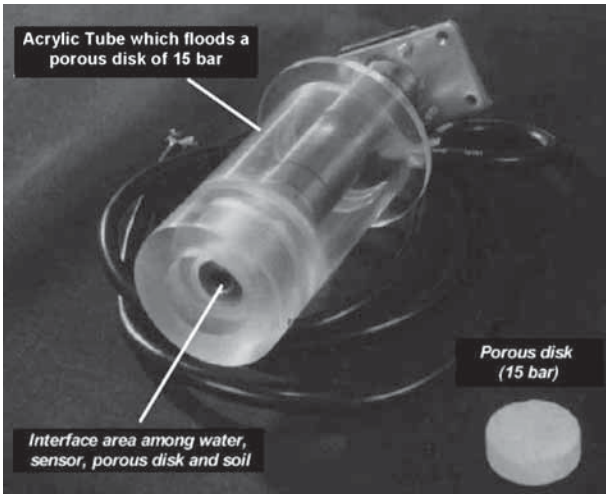

Figure 3 - View of the interface area among water, sensor, porous disk and soil (Pacheco, 2001).

• As expected, the position of the equitensiometer influences the values measured;

• The T5 tensiometer T5 measured values of over 100 kPa (about 150 kPa) quite accurately;

• The mini-lysimeter system proved to be a very good alternative for laboratory tests and for the development of instruments that measure suction;

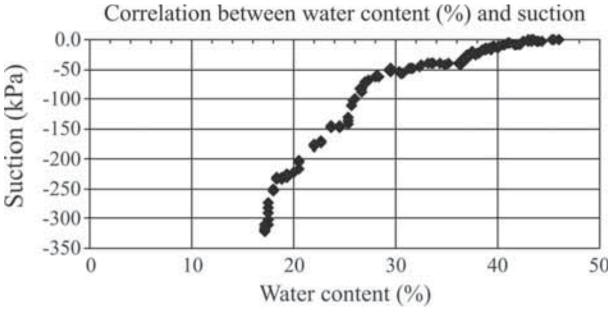

Figure 4 - Correlation between the measurement of the new tensiometer and the TDR probe (Pacheco, 2001).

• Tthe new instrument presented herein proved to be a good and an economical alternative for measuring matrix suction in the soil.

Later, Diene (2004), Mahler & Diene (2004) and Diene & Mahler (2006), among others, continued developing high-capacity tensiometers and managed to measure suction values of nearly 1500 kPa. The characteristic curves determined with high-capacity tensiometer and TDR proves are presented in Fig. 10, while Fig. 11 shows the suction results measured with two high-capacity tensiometers compared with those of a equitensiometer, the

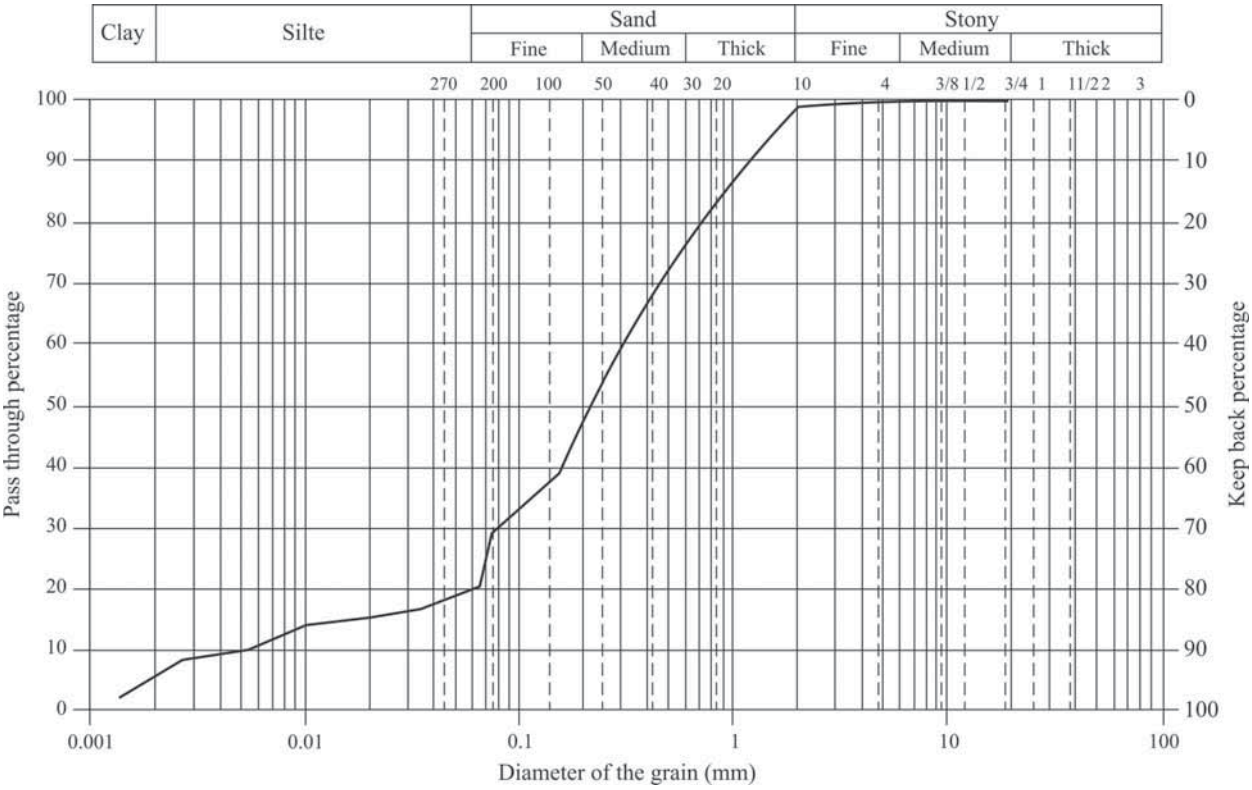

Figure 5 - Grain size curve the soil used (Pacheco, 2001).

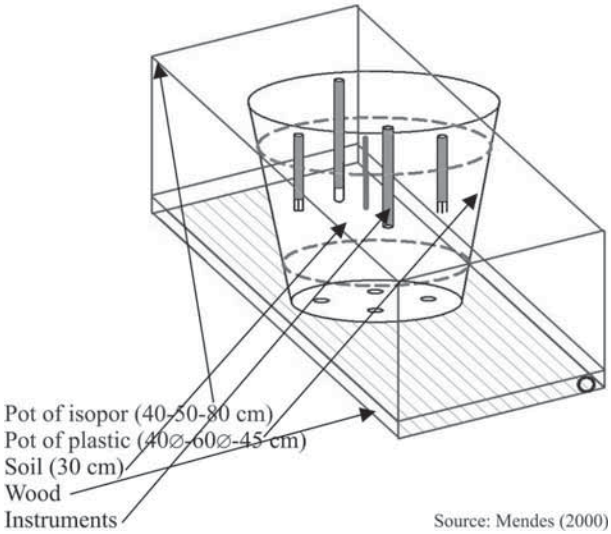

Figure 6 - Mini-lysimeter used in the lab (Pacheco, 2001 and Mahler *et al.*, 2002).

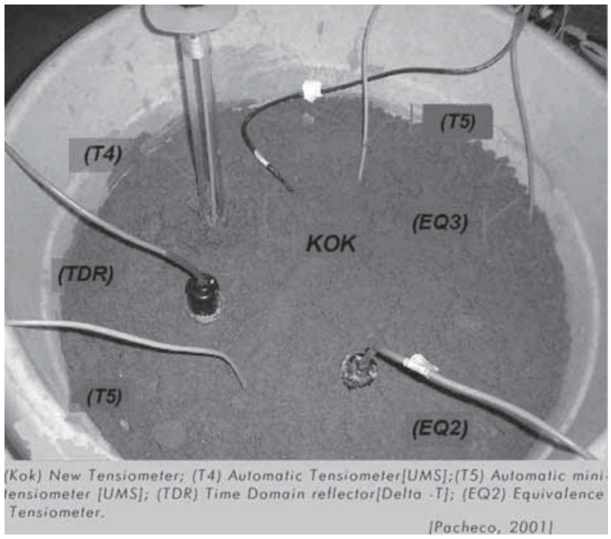

Figure 7 - Position of instruments installed in the mini-lysimeter.

Figure 8 - Equitensiometer (EQ2) [Delta - T Devices].

former having measured values of almost 1500 kPa, as mentioned.

More information on the equipment, procedures and soil used in this study can be seen in the articles cited above and in the master's dissertation of Diene (2004).

The results of the tensiometer presented at the time and those of the equitensiometers placed horizontally and vertically at the same level in laboratory lysimeters were very near.

The procedure used in the experiments carried out by Huse (2007) and Santos (2008) is very similar to that proposed by the authors of the technical note, Marinho & Teixeira. In these two earlier works, a device was developed to study soil drying using a tensiometer, as in the device described by Marinho & Teixeira, but providing more information, such as sample moisture (easily calculated from the sample weight variation) and volumetric variation (obtained directly by the wrapping on the flexible wall around the sample - Fig. 12). In this respect, the device used by Huse (2007) and Santos (2008) is more complete than that presented by Marinho & Teixeira.

One of the results obtained from using the set of equipment to study soil drying is the characteristic curve of

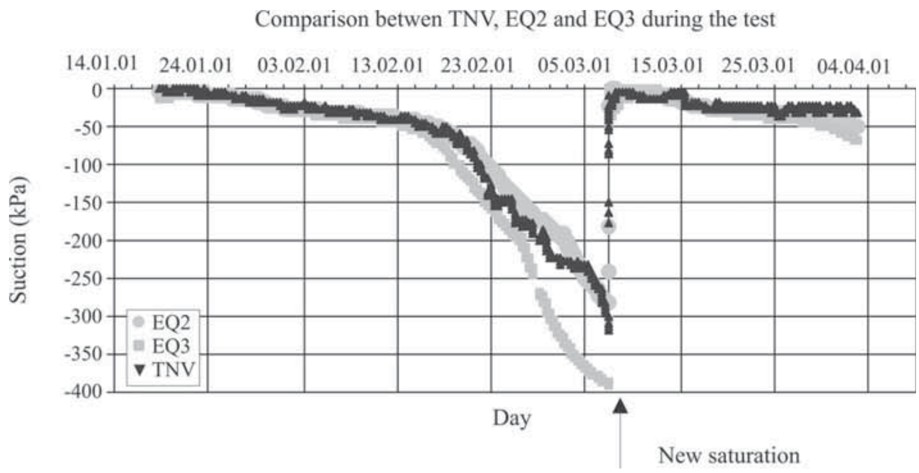

Figure 9 - Results of the new tensiometer and the equitensiometer in the mini-lysimeter (Pacheco, 2001 and Mahler *et al.*, 2002).

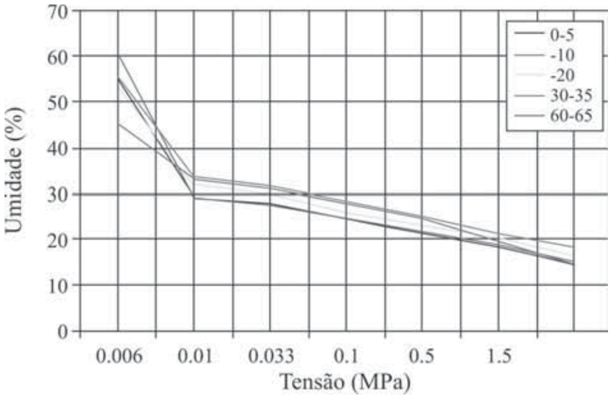

Figure 10 - Characteristic moisture retention curves of the soil from tank B (Laps-Embrapa/Cnps).

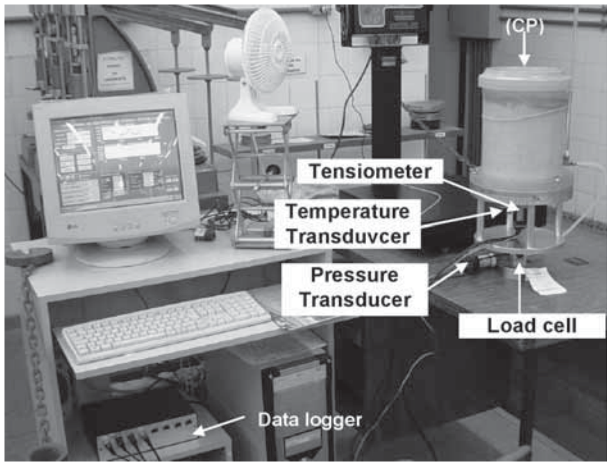

Figure 12 - View of the equipment set-up developed to drying in soil and soil mixed with bentonite (Santos, 2008).

the soil studied, which can be seen in Fig. 13 (Huse, 2006) and Fig. 14 (Santos, 2008).

The study by Huse (2007) was designed to analyze the formation of cracks in landfill cover soil caused by shrinkage from drying, and that by Santos (2008) was aimed at protection of embankments and hillsides. In both cases the authors studied use of mixtures of soil with bentonite.

In closing, it is important to use new types of tensiometers and other equipment to determine the characteristic curves in the laboratory, combined with procedures to determine the moisture content, that associate precision and low cost. The equipment set-up shown above is very flexible. It can be used in various ways and in association with other geotechnical tests.

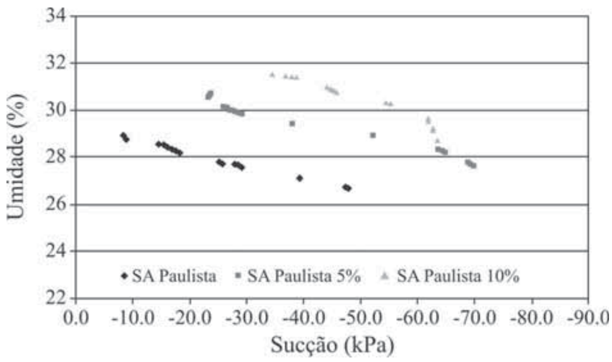

Figure 13 - Characteristic curves obtained by Huse (2006) using the equipment developed to study drying of soil and soil mixed with bentonite.

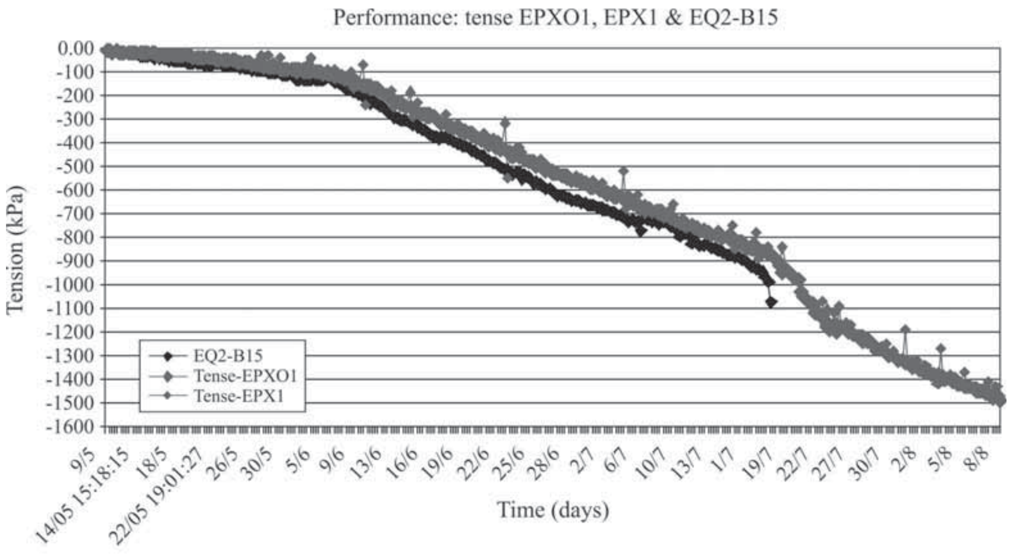

Figure 11 - Suction versus time measurements in two TENSE tensiometers anda n equitensiometer (Diene, 2004).

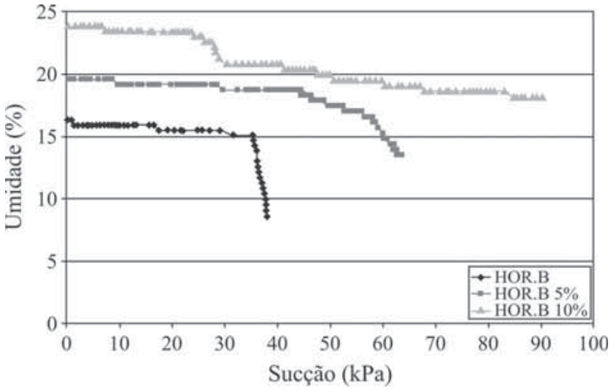

Figure 14 - Characteristic curves obtained by Santos (2008) using the equipment developed to study drying of soil and soil mixed with bentonite.

References

Diene, A.A. (2004) Desenvolvimento de Tensiometros para Sucção Elevada Ensaiados em Lisimetros para Laboratório (Development for High Suction Tensiometers Analysed in Laboratory Lysimeters in the Study of Drainage). Master Dissertation, Departamento de Engenharia Civil, COPPE/UFRJ, 173 pp.

Diene, A.A. & Mahler, C.F. (2007) Um instrumento para medida de potencial matricial nos solos sem ocorrencia de cavitação. Revista Brasileira de Ciência do Solo, v. 31:6, p. 1261-1270.

Huse, K. (2007) Estudo da Formação de Trincas na Camada de Cobertura de um Aterro (Influence of the Top Layer Shrinkage in Water Balance of a Solid Waste Landfill). Master Dissertation, COPPE/UFRJ, 126 pp.

Mahler, C.F.; Pacheco, A.C.C.S. & Goncalves, H.S. (2002) Development of an automatic tensiometer in the laboratory using a Mini-Lysimeter. Proc. 3th International Congress on Unsaturated Soils, UNSAT 2002, Recife, v. 3.

Mahler, C.F.; Diene, A.A. & Goncalves, H.S. (2005) Um novo instrumento para medida de sucção nos solos. Solos e Rochas, v. 28:3, p. 309-318.

Pacheco, A.C.C.S. (2001) Desenvolvimento de um Novo Tensiômetro para Medidas de Tensão Acima de 1 atm (Development of a new tensiometer for suction measurement over 1 atm). Master Dissertation, Departamento de Engenharia Civil, COPPE/ UFRJ, 95 pp.

Ridley, A.M. & Burland, J.B. (1993) A new instrument for measuring soil moisture suction. Geotechnique, 43:2, p. 321-324.

Santos, L.V. (2008) Influencia da Bentonita em um Solo Residual para uso como Camada Selante. (The Influence of Bentonite in a Residual Soil for Use as a Sealant Layer). Master Dissertation, COPPE/UFRJ, 140 pp.