Tension Infiltrometers

FEATURES

- On site determination of hydraulic properties
- Can be used with disc separated from the water tower, or mounted under the water tower
- Requires low volume of water
- Easy adjustable tension settings
- Flow rates can be determined from changes in height of the water column
- Flow rates can also be determined from changes in height of the water column measured with a Tensimeter
- Optional pressure transducers and data logger allow electronic data collection
- Polycarbonate and plexi-glass materials
- Replaceable nylon mesh screen membrane

Tension infiltrometers are designed to measure the unsaturated hydraulic properties of soils. Water is allowed to infiltrate soil at a rate which is slower that when water is ponded on the soil surface. This is accomplished by maintaining a small negative pressure on the water as it is infiltrating into the soil. The saturated hydraulic conductivity of surface soils on the other hand is determined with double ring infiltrometers. With double ring infiltrometers water at atmospheric pressure is allowed to infiltrate soil. The steady infiltration rate measured with double ring infiltrometers is often equated to the saturated hydraulic conductivity. However, because with double ring infiltrometers water is ponded on the soil surface, a large portion of the water might infiltrate through cracks or wormholes, and thus result in very large saturated hydraulic conductivity values, which are not representative for the soil matrix. By applying a small negative pressure (or tension) on the water as it is infiltrating, water will not enter the large cracks or wormholes, but infiltrate into the soil matrix. As a result the measurements obtained with a tension infiltrometer are more representative of the soil as a whole.

20 cm model

The SMS tension infiltrometer is designed to add water to soil at tensions which can be set by the operator of the instrument. By performing infiltration experiments at multiple tensions, one obtains data on the unsaturated hydraulic conductivity at the various tensions. The range of tensions that can be set is for practical reasons limited to a fairly narrow tension range, i.e. 0 to -30 cm H_2O. Note that by setting the tension at or close to zero, on should get an infiltration rate close to the saturated hydraulic conductivity of the soil. Thus the tension infiltrometer can also be used to estimate the saturated hydraulic conductivity.

8 cm model

There are a number of methods to calculate the hydraulic properties from the tension infiltration data. One method is based on the assumption of a log-linear relationship between tension and hydraulic conductivity, as first described by Gardner (1958). This is a valid assumption for the optimum tension range of the infiltrometer. This method can be found in the literature, and is described in detail in the manual that comes with the SMS infiltrometer.

Other methods to calculate the hydraulic properties use inverse parameter estimation methodology to calculate the van Genuchten parameters from the infiltration data (Simunek et al. 1994). A computer program by Dr Simunek to calculate hydraulic properties from tension infiltrometer data is available from SMS.

Field set up

Before placing the infiltrometer on the site where a measurement is to be made, the site is levelled and cleaned from debris. A ring (either 8 or 20 cm in diameter, to be ordered separately from SMS) is placed on the levelled surface, and the area within the ring is filled with fine sifted sand from the area or with silica sand (a few mm in thickness). The sand is levelled carefully, and the ring removed. A perfect flat surface, 8 or 20 cm in diameter, is formed for placement of the infiltrometer. The sand layer should result in good contact between the base of the infiltrometer and the soil below.

By raising or lowering the tube in the bubble tower, the tension that will be maintained at the bottom of the base plate can be set. The maximum tension is generally less than 30 cm. Many researchers start with the highest tension (often 20 cm). Note that at the highest tension the hydraulic conductivity is the lowest, and thus it may take some time for the instrument to start "bubbling".

Data Collection

The SMS infiltrometers are designed to collect data manually, or automatically. Data are collected manually by recording the water level in the supply tower over time. One simply reads the water level in the supply tower at fixed time intervals (i.e. 1 minute: more frequent early on and less frequent during the steady state phase), and records the information together with the time after the start of the experiment.

For multiple sites it is advantageous to use a datalogger to record the data. The water level in the supply tower is then recorded by placing a pressure transducer in the top of the water tower. With a pressure transducer connected to a data logger one measures the negative pressure in the air space in the upper part of the water tower. As the water infiltrates in the soil, and the water level in the water tower decreases, the negative pressure in the water tower becomes less negative. Thus the pressure transducer output is linearly related to the water level in the water tower. Output recorded from the pressure transducer therefore provides a continuous record of the infiltration rate measured with the infiltrometer. A continuous record with frequent readings is important if one is interested in the early, transient infiltration behaviour.

The Data Logging Interface, available from SMS is a convenient way of recording tension infiltrometer data in the field with a laptop computer. With such an interface, using the supplied data logger program, the infiltration rate can be plotted on the computer screen as the infiltration is progressing. This allows one to see if the data collected are as expected. Furthermore one could calculate the hydraulic conductivities in the field.

Another way is to collect the data with an ICT Smart Logger or Logmaster datalogger.

Frequently asked question

1. How can I test my infiltrometer for leaks?

Answer:

1. Separate disc from the infiltrometer tower.
2. Close the clamp(s) on the infiltrometer bubble tower, and close the bottom outlet of the water reservoir with a stopper.
3. Inflate the infiltrometer to about 60 to 100 cm water pressure (60 mbar to 100 mbar).
4. Hold the complete unit under water and check for leaks.

Check the infiltrometer disc for leaks as follows:
(Before installing the mesh screen material, make sure the disc is free from small particles. They may cause leaks. Install a new mesh screen membrane if necessary.)

1. Connect 1/4" tygon tube (60 cm long) to the outlet in the center of the disc.
2. Immerse the disc and tube in a dishpan full of water. The tube should be completely full of water. Make sure there is no air under the membrane or in the tube.
3. Close open end of tube with a tubing clamp or with a small stopper.
4. Remove disc with attached tube from dishpan.
5. Turn the disc, so the screen is facing up.
6. Position tube so end of tube is at the same level as the top of the screen. Open the tube, and slowly lower the end of the tube. Watch if air bubbles appear below the screen. Air bubbles should start appearing when the open end of the tube is 25–30 cm below the level of the screen. This is the bubbling pressure of the nylon fabric.

SPECIFICATIONS

20 cm Model

Diameter Disc: 20 cm

Inside Diameter Water Reservoir: 5.1 cm

Inside Diameter Bubbling Tower: 2.54 cm

Length Water Reservoir: 81 cm

Bubbling Pressure Membrane: 30 cm H_2O

Carrying Case Outside Dimensions: 230 mm x 330 mm x 970 mm

Pressure Transducers: Optional

8 cm Model

Diameter Disc: 8 cm

Inside Diameter Water Reservoir: 2.54 cm

Inside Diameter Bubbling Tower: 2.54 cm

Length Water Reservoir: 81 cm

Bubbling Pressure Membrane: 30 cm H_2O

Carrying Case Outside Dimensions: 230 mm x 330 mm x 970 mm

Pressure Transducers: Optional

7. If air bubbles appear when the tubing outlet is less than 20 to 25 cm below the screen level, then there is a leak in the screen. Replace the screen, making sure that no loose particles are lodged between the screen and the screen support, or between the o-ring and the screen.

2. Should I calibrate my Tension Infiltrometer?
Answer:
You can, and probably should calibrate it. However, all SMS tension infiltrometers are made using the same diameter tubing, and thus the calibration for all tension infiltrometers should approximately be the same. To start with, you can set the tube in the bubble tower such that its outlet is 4.7 cm below the desired tension. For example, if a tension of 5 cm is desired at the level of the membrane, move the tube in the bubble tower up or down till its outlet is at 9.7 cm below the water level in the bubble tower.

After you have had some experience with the tension infiltrometer, you may want to check its calibration.

3. What is the difference between the 8 cm model and the 20 cm model?
Answer:
The 8 cm model is smaller and uses less water. It can also be used in a smaller space. However, the disc surface is considerably smaller than the disc surface of the 20 cm model, causing greater variance in the measurements. The 8 cm model is good for measurements between crop rows, and is also very good for teaching purposes.

4. Can I replace the membrane in the field.
Answer:
Yes this can be done quite easily. Remove the old membrane after loosening the holding ring. Wet the new membrane (this makes it much easier to install), place the new membrane over the disc, replace the holding ring, tighten the screw, and you are done.

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