Saturated Hydraulic Conductivity Study

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Objectives:

1. To evaluate variability problems in the saturated hydraulic conductivity method.
2. To develop a revised method for quantifying saturated hydraulic conductivity for rootzones for use by the testing lab industry.

Start Date: 1999
Project Duration: 3 years
Total Funding: $60,000

In 1999 a research project was initiated by the USGA Green Section to investigate sources of interlab variability associated with ASTM Method F1 815-97, with specific attention to the determination of Saturated Hydraulic Conductivity.

Rootzone 30-cm moisture retention is fundamental to the saturated hydraulic conductivity (SHC). Rootzone samples are first saturated and placed on a tension table to equilibrate the rootzone moisture content prior to compaction. In 1999, nine USGA-PT laboratories were asked to destructively sample rootzone mixes to evaluate the initial 30-cm moisture retention, Step #3 of the method. Results indicated that the initial moisture contents were consistent and closely related to the final 30-cm moisture retention determined at the last step of the method.

The moisture content and packing procedures of sand-rootzone test columns affect the accuracy and precision of saturated hydraulic conductivity measurements.

Subsequent to early attempts to develop a predictive model of 30-cm moisture retention an additional factor was found which impacted SHC. It was found that the moisture content of the rootzone mix prior to loading the cylinder (Step #1) had a major influence on the SHC. As the moisture content of the rootzone mix increased from 2% (w/w basis) the SHC value determined at Step #6 of the procedure decreased. The amount of decrease was determined by the rootzone mix, but for several rootzone materials, an increase of 5% in initial moisture decreased the SHC by 40%. The effect of antecedent moisture was replicated across five testing laboratories and five rootzone materials.

The actual phenomena which moisture content influences SHC is not well understood, but is believed to be related to the cohesion of fine and coarse grain particles to one another in conjunction with the increasing thickness of water films. Using the current SHC method, low antecedent moisture leads to a greater proportion of non-cap fraction macro-pores, whereas high moisture leads to a decrease in macropores in the non-capillary fraction which impedes water flow and results in low SHC.

In reviewing the antecedent moisture research one clear effect was noted. As antecedent moisture content of the rootzone material increased there was no or little effect in the capillary, non-capillary moisture and bulk density values of the rootzone mixes evaluated, but a large effect on SHC. Antecedent moisture thus affected pores with a tension less than 30 cm, (larger pores) and possibly the connectivity of the macropores, but not those with greater tension: smaller pores. Thus antecedent moisture impacts the current SHC procedure at the initial step and modifies the macropore distribution and SHC values measured at Step #6 of the method.

A predictive model of 30-cm moisture retention based on rootzone physical parameters was developed from individual laboratory databases was proposed. Its development was based on related work in 1995 in Germany, which found that fine sand, very fine sand and organic matter could be used to develop a predictive model of rootzone moisture content. Primary variables for the models included organic matter, very fine sand, and coarse sand contents. The model successfully predicted 65 - 80% of the variability in 30-cm moisture retention.

Summary Points

- In 1999, a research project was initiated by the USGA Green Section to investigate sources of interlab variability associated with ASTM Method F1 815-97, with specific attention to the determination of saturated hydraulic conductivity. Results of the USGA-PT'program have indicated interlab variability of 25% or more for 42 rootzone mixes evaluated since January, 1997.
- Results of the laboratory visits indicate inconsistency between laboratories in Steps #1 (loading the rootzone in the test cylinder, see Appendix A), Step #2 (initial saturation of the rootzone mix), Step #3 (initial 30-cm moisture tension) and #6 (measurement of water flow) of the method.
- Research has evaluated two approaches to resolving the inter-lab variability of ASTM F1 815-97 and developing a more robust method. The first addresses subjective steps in the method and improving the method description. The second proposes to revise the existing protocol, remove problematic steps, and utilize a predictive moisture model.