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Measuring water infiltration rates

By Michael Dukes, Grady Miller and Justin Gregory

Infiltration is the process by which water enters the soil from its surface. This process affects surface runoff, soil erosion, and groundwater recharge. Being able to measure infiltration rate may be beneficial in designing sports field maintenance strategies.

The double-ring infiltrometer is the instrument most often used for measuring infiltration rates. Infiltrometers are often constructed from thin walled steel pipe with the inner and outer cylinder diameters being 8 and 12 inches, respectively; however, other diameters may be used.

A ring infiltrometer consists of a single metal cylinder that is driven partially into the soil. The ring is filled with water, and the rate at which the water moves into the soil is measured. This rate becomes constant when the soil becomes saturated.

Photograph of 12-inch diameter (inner) and 24 inch diameter (outer) double ring infiltrometer (left/A); 6-inch diameter (inner) and 12 inch diameter (outer) double ring infiltrometer (center/B), and Mariotte siphon developed to maintain a constand inner head in the infiltration rings (right/C).

The size of the cylinder is one source of error. A 6-inch diameter ring produces measurement errors of approximately 30%, while a 20-inch diameter ring produces measurement errors of approximately 20% compared to the infiltration rate that would be measured with a ring of an infinite diameter. It has been suggested that a diameter of at least 40 inches should be used for accurate results. However, cylinders of this size become very difficult to use in practice on light soils, because large volumes of water are required to conduct tests on sandy soils with high infiltration rates.

Single ring infiltrometers overestimate vertical infiltration rates. This has been attributed to the fact that the flow of water beneath the cylinder is not purely vertical. Double ring infiltrometers minimize the error associated with the single ring method because the water level in the outer ring forces vertical infiltration of water in the inner ring.

Another possible source of error occurs when driving the ring into the ground, as there can be a poor connection between the ring wall and the

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ANOTHER POSSIBLE SOURCE OF ERROR OCCURS WHEN DRIVING THE RING INTO THE GROUND, AS THERE CAN BE A POOR CONNECTION BETWEEN THE RING WALL AND THE SOIL.

soil. This poor connection can cause a leakage of water along the ring wall and an overestimation of the infiltration rate. Placing a larger concentric ring around the inner ring and keeping this outer ring filled with water so that the water levels in both rings are approximately the same reduces this error.

There are two operational techniques used with the double ring infiltrometer for measuring the flow of water into the ground. In the constant head test, the water level in the inner ring is maintained at a fixed level and the volume of water used to maintain this level is measured. In the falling head test, the time that the water level takes to decrease in the inner ring is measured.

In both constant and falling head tests, the water level in the outer ring is maintained at a constant level to prevent leakage between rings and to force vertical infiltration from the inner ring. Models have shown that falling head and constant head methods give very similar results for fine textured soils, but the falling head test underestimates infiltration rates for coarse textured soils.

The ASTM standard describes a procedure for measuring the soil infiltration rate with a double-ring infiltrometer for soil with a hydraulic conductivity less than 4 inches per hour. The ASTM standard specifies inner and outer ring diameters of 12 and 24 inches, respectively.

The primary objective of this research was to compare falling head and constant head double ring tests with 6 and 12-inch rings and a constant head test with 12 and 24-inch diameter rings. A secondary objective was to develop a simple device to automatically maintain a constant water level in 6-inch diameter inner ring.

Measurement methods

An area at the Irrigation Park on the University of Florida campus in Gainesville was used to conduct the double-ring infiltrometer tests. The

soil was fine sand, which had been tilled and allowed to settle for several months. Soil textural analysis indicated 92% sand, 4.5% silt, and 3.1% clay.

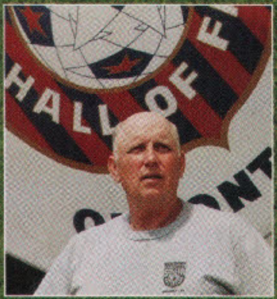
The three types of tests that were evaluated were: A, the ASTM standard 12-inch (inner) and 24-inch (outer) double-ring infiltrometer under a manually maintained inner ring constant head; B, 12-inch (inner) and 24-inch (outer) infiltration rings under an inner ring constant head with a Mariotte siphon; and C, 12-inch (inner) and 24-inch (outer) infiltration rings under a falling head.

In all three types of tests, the outer ring was maintained manually at a constant head. Maintaining a constant head in the outer ring was not as critical as maintaining constant head in the inner ring to measuring infiltration rates since the purpose of this head is to reduce the leakage of water between rings; therefore, maintaining the head manually was sufficient. The 6 and 12-inch infiltration ring size is typically used in turfgrass systems such as athletic fields for infiltration measurements. In many cases, the falling head test is preferred since less water and time is required to complete a test.

The thin aluminum infiltrometer rings were driven into the ground approximately 6 inches for (A) and 2 inches for (B) and (C). A Mariotte siphon was manufactured from a 4-inch inner diameter Plexiglass pipe cut to a length of 47 inches (see photo). This resulted

Table 1. Statistical analysis of infiltration rates (K) from three types of infiltration tests.

(A) ASTM standard with 12 and 24 inch diameter rings		(B) Constant head with 6 and 12 inch diameter rings		(C) Falling head with 6 and 12 inch diameter rings	
Test no.	K (inch/h)	Test no.	K (inch/h)	Test no.	K (inch/h)
1	4.7	1	3.1	1	6.3
2	5.8	2	8.8	2	2.2
3	4.3	3	6.7	3	5.0
4	6.4	4	7.7	4	3.9
5	----	5	8.2	5	7.3
6	3.4	6	7.5	6	3.1
7	6.0	7	7.9	7	7.7
8	6.0	8	5.9	8	4.7
9	0.8	9	7.6	9	5.0
Mean	**4.7**	**Mean**	**7.0**	**Mean**	**5.0**



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in approximately 3 gallons of water storage, sufficient to keep a constant head in a 6-inch diameter inner ring for more then 4 hours assuming an infiltration rate of 6 inches per hour and for 1 hour assuming an infiltration rate of 27 inches per hour. The 12-inch diameter inner ring used in the ASTM Standard test would require approximately 13 gallons of water to keep a constant head for 1 hour assuming an infiltration rate of 27 inches per hour.

The water level in the outer ring was maintained manually by adjusting a flow valve on a water container (10 gallons) that was used to supply water to the outer ring of the double ring infiltrometer. Alternatively, another Mariotte siphon could be used to maintain a constant water level in the outer ring; however, the water level could be maintained manually with sufficient precision to minimize lateral flow or leakage from the inner ring. Cumulative infiltration and time were recorded, with each test generally lasting 40 to 90 minutes for the constant head test and approximately 20 to 30 minutes for the falling head test. The bulk density and moisture content of the soil were measured adjacent to each test site before each infiltration test was conducted. The infiltration rate was found by regressing the recorded cumulative infiltration and time data.

Evaluation

The table shows the results of the measured infiltration rates from the three different testing methods. Measured infiltration rates on the sandy soil ranged from 0.8 to 8.8 inches per hour and averaged 5.6 inches per hour over all tests. These rates are representative of moderately compacted fine sandy soils. Testing methods (A) and (C) resulted in a significantly lower mean infiltration rate (4.7 and 5.0

inches per hour, respectively) compared to method (B) at 7.0 inches per hour. This difference was expected for the falling head test (C) since the depth of water in the inner ring, one of the components of total head that causes infiltration, decreases during the test. Test (B) had the lowest variability compared to tests (A) and (C). Soil moisture was not different across testing locations, nor was soil bulk density.

It was concluded that the test using a constant head with a double-ring infiltrometer of 6 inches inner diameter and 12 inches outer diameter would be suitable for infiltration research on the sandy soils. These soils have similar infiltration rates to athletic fields built to USGA specifications with mature turf. This allows for infiltration tests to be conducted in areas where the methodology suggested by ASTM would not be suitable due to the volume of water required to maintain a constant head in the larger diameter double-ring infiltrometers can not be easily transported to the site.

The set-up of the double-ring infiltrometer with the Mariotte siphon is an efficient method of conducting a double ring infiltrometer test. The Mariotte siphon automatically maintains a constant head in the inner ring, while the head in the outer ring is maintained manually (a second Mariotte siphon could be used for this). This testing procedure therefore only requires one person to maintain the head in the outer ring and record the change in water level in the siphon. The volume of water that is needed for this test can also be managed by a single person compared to the large volume of water needed to conduct the ASTM standard test.

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President's Reflections: 2005-2006 Goals

In early 2005, the STMA Board of Directors developed an aggressive plan around seven goals. The goals are:

Goal I: Increase membership/certified members.

Goal II: Enhance the image of members and the profession.

Goal III: Effectively influence our external and internal audiences through our communication vehicles.

Goal IV: Strengthen and improve the competency of members effectively utilizing the limited resources of STMA.

Goal V: Make the STMA Conference the must-attend industry event of the year.

Goal VI: Effectively manage STMA's resources through solid fiscal procedures, efficient operations, and a strong board governance/committee structure.

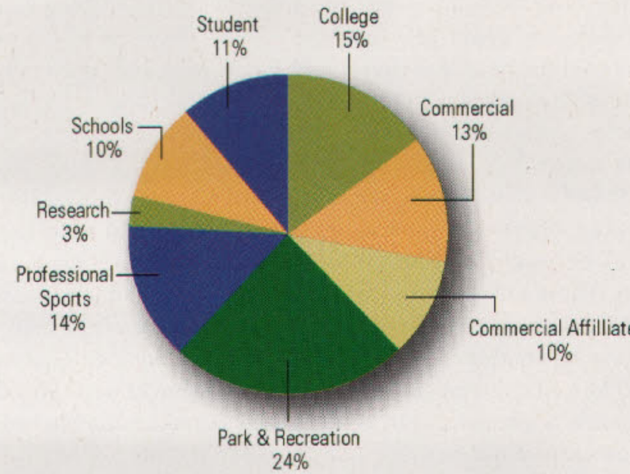
Goal VII: Strengthen the STMA chapter network.

I am happy to report that STMA has achieved significant progress on these goals. Our membership numbers including certified sports field managers have increased. Our efforts in public relations and with allied associations are bringing more recognition to the profession and to our members. Our conference education program is the strongest it has ever been, and we're using web technology to bring more information, education and resources to members. Our magazine, *SportsTurf*, delivers timely and relevant information. Our STMA "house is in order," with solid fiscal health, and our chapter network is growing in numbers and in strength. Because these goals are of great consequence, they will always be important to the business of STMA. As we set new goals and put plans in place to attain them, we will continue our efforts to advance these essential benchmarks.

Mike Trigg

Mike Trigg, CSFM
STMA President

Membership Representation



STMA Profile

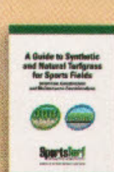
- Formed in 1981
- Members representing 15 countries
- 26 chapters
- 68 certified members
- 12-member board/3 full-time & 1 part-time staff
- $1 million budget
- 18 committees/subcommittees

STMA Member Profile

- 100 percent use the internet, and 78 percent primarily use it at the office
- 90 percent of those who attend conference have all or partial costs paid by their employer
- 84 percent have been sports turf managers for 6+ years
- 84 percent have all or partial STMA dues paid by their employer
- 79 percent are members of their local chapter
- 69 percent have an associate, bachelor or post-graduate degree
- 63 percent attend the annual conference and show

2006 First Six Months Timeline

January 2
New *SportsTurf* magazine debuts



January 5
Introduction of the publication, *A Guide to Synthetic and Natural Turfgrass for Sports Fields*

January 17
Induction of the newest STMA Chapter, Sports Turf Managers of New York (STMONY), to the STMA national chapter network

January 18-22
STMA 17th Annual Conference celebrates the association's 25th Anniversary. Total attendance (includes exhibitors) 1,541. SAFE Auctions and Golf Tournament raises $31,941.