Understanding the Hydrology of Modern Putting Green Construction Methods

The Ohio State University - OARDC

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Number of Years: 5
Total Funding: $100,000 (co-funded with the GCSAA)

Objectives:

1. *Examine the effects of rootzone composition and putting green construction method on water drainage and redistribution within the profile.*
2. *Examine the effects of rootzone compostition, soil depth and degree of water perching on turf water use and irrigation management.*
3. *Examine long-term changes in physical, biochemical and microbiological properties of the rootzone; and relate these changes to the long-term hydrologic behavior of modern putting green designs.*

The overall program, co-funded by the USGA and GCSAA, investigates the influence of green construction method on hydrologic processes including water infiltration, redistribution within the rootzone, drainage, and uptake by the turf. The study is subdivided into Phases I and II. Phase I focuses on water redistribution and drainage as influenced by soil profile design, root zone composition and green slope. Phase II focuses on turf water use in a USGA profile as influenced by root zone composition and depth.

Phase I. The results included in this report are essentially a repetition of our project conducted in the fall of 1997. In the earlier study, the greens were just one year old and had not received any compaction treatments to simulate foot traffic. Prior to our spring 1999, Phase I work, we applied a compaction treatment to the greens by using a weighted roller. The roller is 4 ft in length, 8 inches in diameter and has a weight of about 325 lbs. The 'rolling factor' for this roller is about 1.2 and simulates the heel pressure of an average human. In addition, the greens of the 1999, Phase I research had aged an additional 20 months.

Drainage of the experimental greens was expressed as cumulative outflow vs. time after rain application was stopped. Measurements were taken 1.5 hours prior to rain ending and continued for the 48 hours. At 0 percent slope under the high rainfall rate conditions, the low permeability USGA rootzone without the gravel had very low drainage rates compared to all other experimental greens. During this same period, both USGA greens and the high permeability USGA rootzone without the gravel layer exhibited relatively higher drainage rates. Drainage rate differences between these greens will require further statistical analysis to determine if differences exist.

After rainfall stopped, drainage from the USGA greens slowed substantially since the cumulative outflow curve quickly became almost flat. The USGA rootzones without the gravel layer, on the other hand, showed continued drainage although at a slower rate than during rain application. The much lower cumulative outflow after 48 hours from the low permeability USGA rootzone without the gravel layer was the result of the infiltration rate being less than the rainfall rate. The excess rainfall occurred as runoff and did not enter the soil profile.

At 4 percent slope under the high rainfall-rate conditions, both USGA greens exhibited high and nearly equivalent drainage rates. Again, the low permeability USGA rootzone without the gravel layer had a very low drainage rate with the high permeability rootzone and no gravel layer intermediate. After rainfall stopped, drainage from the USGA greens slowed substantially, similar to that observed for 0 percent slope. The greens without a gravel layer, on the other hand, showed continued drainage although at a slower rate than during rain application. Indeed, these greens continued to drain at a reasonable rate for the full 48 hours. The overall reduced cumulative drainage from these greens was due to excess runoff that was not apparent in the USGA profiles with a gravel layer.

Soil water content (% by volume) as a function of profile depth (inch) and distance up slope (feet) was measured at 0, 1, 3, 9, 27, and 45 hours after rainfall stopped. Results for the low rainfall rate treatment were quite similar to that for the high rainfall rate. The high permeability USGA rootzone without the gravel layer at 0 percent slope showed virtually a textbook example of soil drainage after rainfall. As rainfall ended (0 hours) there was a lateral pattern of higher water contents between the drain lines and lower water contents above the drain lines and near the soil surface. As the soil drained, this pattern was maintained as overall water contents declined. An equilibrium condition developed at 27 hours with a vertical gradient of increasing moisture with depth and a lateral gradient of decreasing water contents over the drain lines. Little change in this situation was observed after 45-hours drainage. A very similar response was observed early in the drainage period when these greens were sloped at 4 percent. At 27 hours, however, there was a trend of increasing soil water contents at the down slope locations. Further, additional drainage occurred from 27 to 45 hours. This led to an overall drier root zone at 45 hours and an accumulation of soil moisture, at the furthest down slope location, for the 4 percent slope as compared to the 0 percent slope condition.

The low permeability USGA rootzone without the gravel layer at 0 percent slope maintained high soil moisture throughout the period of this study. Additionally, there was little evidence that an open drain line was present at 17 feet up slope. This was not expected, and reasons for this seemingly ineffective drain line will require further research for an explanation. Equilibrium conditions again appeared after 27 hours with little further drainage after 45 hours. Again, a very similar response was observed early in the drainage period when these greens were sloped at 4 percent. At 9 hours, a trend began to develop with increasing water contents at the down slope locations. This trend strengthened after 27 hours resulting in about a 15 percent difference in water content from the down slope to the furthest up slope location. Unlike the high permeability rootzone without the gravel layer at 4 percent slope, equilibrium conditions appeared to be established after 27 hours for the low permeability rootzone.

Except for some edge effects, the USGA high permeability greens at 0 percent slope exhibited uniform root zone moistures early in the drainage period. Additionally, this system had drier soil conditions than the high permeability rootzone without the gravel layer. As drainage progressed a slight trend of higher water contents with depth developed. Perhaps due to antecedent conditions, there was also a slight trend of higher water contents at the down slope locations even for this 0 percent slope configuration. Regardless, the major portion of the root zone from 9 to 45 hours averaged 20 percent volumetric water content. A similar behavior was observed for the USGA high permeability greens at 4 percent slope. There was, however, a more pronounced tendency for water accumulation at the down slope locations resulting in an 8 percent difference from the extreme down slope location to the extreme up slope location.

Results for the USGA low permeability greens at 0 percent slope were similar to the USGA high permeability greens except for the expected high water contents throughout the drainage period. Consequently, water contents throughout were about 4 percent greater for this treatment than the USGA high permeability system. This system did not exhibit the high water contents of the low permeability USGA rootzone without the gravel layer. When positioned at a 4 percent slope, the USGA low permeability system was again similar to the USGA high permeability greens with again about 4 percent greater water content.

One apparent difference between the 1997 and the 1999 data from our Phase I research was generally higher water content for most treatments in 1999. A second difference was the very low drainage rates and absence of drain line effects on soil moisture for the low permeability USGA rootzones without the gravel layer. More subtle differences will likely appear after complete statistical analysis.

Phase II. This research examines turf water use as influenced by green construction method. This was conducted as a 'dry down' study wherein water was withheld for a period of 10 days during which soil moisture status and turf response were monitored. The Phase II results should, however, be viewed as preliminary in that only one dry down cycle was completed. Additional cycles will be conducted in the summer