

# **Understanding changes in physical properties of USGA greens.**

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Defining the dynamic changes that occur to physical properties within USGA greens is typically very difficult. These changes often dictate the long-term success or failure of such greens.

## **What don't you know?**

Physical property testing is normally limited to new mixes with little consideration given to greens after they have been established. Additionally there are currently few established guidelines for physical properties of established turf systems.

This is unfortunate as measuring and understanding the changes that take place within the sand based rootzone allows superintendents to be more proactive with regard to cultural practices that affect physical properties. In addition the careful monitoring of changes in physical properties allows these practices to be assessed.

## **A Starting Point**

In 1960 the USGA published its first specifications for putting green construction. An acknowledged contributor to those initial specifications was Leon Howard MS. With the help of Dr. Marvin Ferguson, Leon Howard set about the task of identifying the propensity of various root zones to compact. His USGA funded 1959 masters thesis titled 'The Response Of Some Putting Green Soil Mixtures To Compaction', analyzed 45 various mixes seeded with bent grass in simulated turf plots at Texas A&M University.

“The primary object of this study was to gain a better understanding of the fundamental factors involved in producing a satisfactory turf where conditions conducive to soil compaction are prevalent”.

Leon Howard Masters Thesis 1959 (1)

## **Replication**

In 1991 with the help of Leon Howard, David L.Doherty founded the International Sports Turf Research Center. ISTRC, 'pronounced *'istr-k'* has analyzed thousands of undisturbed core samples with an idea to better understand the changes in physical properties of existing turf grass systems. The methods used for Leon Howard's Masters Thesis were adopted so as to ensure comparisons with the initial research would be both accurate and meaningful.

## **Sample Collection**

The samples were collected using a tool called 'The Plugger' (2) which was used by Leon Howard to ensure the accurate sampling of root zones for his earlier

research. The Plugger inserts a 2" diameter x 4" deep copper sleeve into the rootzone. This is removed with the rootzone sample contained within the sleeve intact including the turf, root mat, organic layers and roots. It is then capped at both ends ensuring the integrity of the sample.

This method of core sampling is preferable from that of driving a PVC pipe into the rootzone as the greater sample depth of the PVC core is found to create excessive compaction of the sample. In addition, infiltration rates can be distorted due to scoring of the PVC by larger sand particles. Integrity of the test results is extremely important when trying to discern differences between core samples taken at different dates with a view to adjusting cultural practices based on the results.

## **The Basics**

For many years it has been suggested that an adequate rootzone should contain a 50% ratio of solids to pore space. Of this pore space 25% should represent Non Capillary (Air pores) and 25% Capillary (Water Pores). This is the important first step in understanding the physical properties of the sand based rootzone.

## **Real World**

The following table represents the physical properties of an undisturbed core sample taken from a two-month-old green constructed to USGA recommendations (4) using an 85/15 blend of sand and peat. The green was seeded with one of the newer varieties of bent grass.

<b>August 1997</b>		<b>Green at 8 Weeks old</b>	
Infiltration (in/hr)		36.92	
Air Porosity		27.11 %	
Water Porosity		13.63 %	
Water Holding		9.95 %	
Solids		59.26 %	
Organic 0-1"		1.08 %	
Organic 1-2"		1.04 %	
Organic 2-3"		0.85 %	
Organic 3-4"		0.90 %	



- ◆ In this early stage the rootzone has an extremely high infiltration rate.
- ◆ The water porosity is minimal at 13%.
- ◆ There is already a slight increase in organic content in the top two inches.

Additionally the total porosity is only 40%, well below the previously mentioned 50% total porosity. This is found to be a more typical representation of greens built to USGA recommendations.

### **Developing Rootzone**

Follow up testing one year later of the same green in the same area demonstrates significant changes from the original tests.

	August 1997	September 1998
Infiltration (in/hr)	36.92	<b>4.42</b>
Air Porosity	27.11%	<b>21.57%</b>
Water Porosity	13.63 %	<b>22.37%</b>
Water Holding	9.95 %	<b>15.67%</b>
Solids	59.26 %	<b>56.06%</b>
Organic 0-1"	1.08 %	<b>1.17%</b>
Organic 1-2"	1.04 %	<b>0.79%</b>
Organic 2-3"	0.85 %	<b>0.81%</b>
Organic 3-4"	0.90 %	<b>0.68%</b>



- ◆ Infiltration rate has dropped dramatically
- ◆ Air porosity has decreased
- ◆ Water Holding has increased significantly

The second sample indicates an interesting phenomenon, which is the reversal of air and water pores with only a minimal change to the total porosity. The primary reason for this is the occupation of the air pores by plant matter and the subsequent changing of these larger pores into a greater number of smaller capillary - water pores. The decrease in infiltration is primarily due to the dense plant matter rather than the addition or compaction of organic matter.

## The Mature Rootzone

At two years old we consider the green to have reached a 'mature' condition. Its initial early growth and root mass have slowed to a more normal pace and the green is subjected to regular topdressing and an aerification program consisting of two applications of larger hollow quads annually.

	Aug 1997	Sep 1998	Sep 1999	Sep 2000
Infiltration (in/hr)	36.92	4.42	<b>1.50</b>	<b>1.21</b>
Air Porosity	27.11 %	21.57 %	<b>18.93 %</b>	<b>17.16 %</b>
Water Porosity	13.63 %	22.37 %	<b>24.31 %</b>	<b>27.58 %</b>
Water Holding	9.95 %	15.67 %	<b>17.11 %</b>	<b>19.91 %</b>
Solids	59.26 %	56.06 %	<b>56.76 %</b>	<b>55.26 %</b>
Organic 0-1"	1.08 %	1.17 %	<b>1.98 %</b>	<b>2.40 %</b>
Organic 1-2"	1.04 %	0.79 %	<b>0.91 %</b>	<b>1.15 %</b>
Organic 2-3"	0.85 %	0.81 %	<b>0.74 %</b>	<b>1.02 %</b>
Organic 3-4"	0.90 %	0.68 %	<b>0.96 %</b>	<b>0.88 %</b>

- ◆ Infiltration rate has dropped to a consistent rate  
(Note all samples are collected immediately prior to aerification in late fall – representing the worst physical properties encountered during the year)
- ◆ Continued reversal of air and water pores
- ◆ Organic layering becomes more pronounced
- ◆ Note movement of organic through aerification hole



SEPT 2000

The second and third year testing demonstrates the mature condition the green has reached. Its infiltration rate has stabilized. The organic layering which is visibly evident in the time-lapse photographs has increased considerably since the initial tests. Note that at the 3-4 inch depth there has been little increase in organic material demonstrating that the organic matter deposited in the rootzone is confined to the surface of the rootzone.

While no two greens are exactly alike the information presented represents a scenario, which is repeated in greens nationwide and demonstrates the typical aging of physical properties within a sand based rootzone.

### **What Does This Mean?**

**Infiltration Rate** is measured at a saturated condition. This means that all the pore space contained in the sample is saturated with water prior to the sample being placed on a permeameter to measure the percolation rate. This measurement quantifies the ability of the rootzone to accept water, however of greater importance is the ability of the rootzone to exchange gases with the atmosphere, in effect the ability of the rootzone to ‘breathe’.

**Air Porosity** represents the larger non-capillary porosity of the sample. This figure will greatly affect the percolation rate. It is this pore space that the plant occupies, and is therefore one of the major factors that dictate the success of a rootzone to support the plant. (3)

While an initial test of a new rootzone mix may demonstrate that the material will have sufficient air porosity what must be taken into account is the degradation of these air pores over a relatively short period of time as the plant occupies these air pores. This may result in a rootzone with insufficient air pores to support the plant. Typically the air pores contained within a new rootzone will decrease by a minimum of 40% during the first few years.

**Water Porosity/Holding** is a figure, which changes dramatically within the first few years. As demonstrated, it is not unusual to see a 100% increase in water porosity within the first two years. This may be of particular importance when irrigation water is questionable. Of greater importance may be its relationship to air porosity and total porosity rather than as a single entity.

**Organic Content** is perhaps one of the most important factors which affect the possible demise of a sand based rootzone. A straight sand component is very difficult to compact to any degree. However when the organic content of the top inch (as demonstrated) approaches 3% it, in combination with the sand particles becomes very readily compacted and has the ability to seal off a rootzone regardless of how conducive the material below may be to supporting healthy turf. It is the manipulation of this layer by aerification that is perhaps the greatest safeguard in ensuring the long-term integrity of the rootzone.

## **Conclusions**

While this data only represents a single green it has been selected as it readily demonstrates the changes that are represented in all sand based root zones to some degree.

The main benefit derived from such testing appears to be a better understanding of the dynamic changes that occur within a sand based rootzone. Armed with this information cultural and maintenance practices become pro-active and quantifiable events, aimed at ensuring the long term viability of the rootzone to provide the physical properties necessary to support healthy turf.

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