# CHALLENGES IN GREEN CONSTRUCTION RESEARCH

**James T. Snow**
**National Director, USGA Green Section**

**Successful greens depend on many factors, including:**

- Proper design
- A good growing environment
- Proper construction
- Appropriate grow-in procedures
- Good long-term management
- Reasonable expectations from the golfers

**Considering that the USGA green construction recommendations were published in 1960, why is research needed now?**

- Play has increased significantly.
- Greens are maintained differently.
- Golfers demand speed and perfection.
- New grasses have been developed.
- Use of non-potable water has increased.
- Many new amendments and other products have been introduced.
- We need to understand the scientific basis for, and the benefits and problems associated with, other methods currently being used to build greens.
- We need to be able to offer viable, if not ideal, methods of green construction to facilities with restricted budgets.
- We want to help golf courses build the best possible greens!!

**The research goal of the USGA Turfgrass & Environmental Research Committee as it pertains to green construction issues is as follows:**

Identify the best combinations of construction methods, grow-in procedures and post-construction maintenance practices that 1) prevent long-term problems, 2) minimize environmental impacts, and 3) produce high quality playing surfaces at a reasonable cost.

**Green Construction Research**

- Currently, eleven projects are being funded. GCSAA is co-funding five studies.
- Half are nearly completed, while the others will require 5-10 years.
- More than $1 million is being spent during the period 1996-2000; additional research will be funded beginning in the year 2000.

## Current Projects
## (none have been completed)

**Engineering Characteristics of Golf Putting Greens – Michigan State University**

*Objectives:*

- Investigate the physical properties of sands.
- Establish relationships between strength and stability.
- Develop guidelines to help golf courses find the most effective and stable sand.

*Conclusions to-date:*

- Greens can be modeled as an elastic spring that has some stiffness.
- The stiffness of the rootzone sand increases with higher coefficient of uniformity.
- The median grain size has no effect on the stiffness of the sand.
- The stiffness of the green is dependent on soil properties, but is increased due to the strength contributed by the root structure of the turf.
- Investigators believe that guidelines can be developed to design a sand mixture that will achieve good results and still meet USGA guidelines.

**Effects of Sand Shape on Root Zone Physical Properties – Penn State University**

*Objectives:*

- Develop a simple way to determine sand shape.
- Determine how sand shape affects green performance.
- Determine how sand shape affects particle size distribution requirements for the rootzone mix.

*Conclusions to-date:*

- Sub-rounded sand has the best compaction resistance. Sub-angular, round, and angular sands are 2%, 9%, and 37% more compressible than sub-rounded sand.
- Overall, sub-round sand has the best combination of compaction resistance and strength, and sub- angular sand is second.

**Layers in Green Construction – Sports Turf Research Institute, England**

*Objectives:*

- To examine particle migration from the rootzone layer into underlying gravels of increasing size in situations where no intermediate layer is present.
- To assess the effects of different intermediate and drainage layers on moisture retention in the rootzone layer.
- To review the particle size criteria for the selection of intermediate layer and drainage layer materials.

*Conclusions to-date:*

- Study found that up to 50% of the particles in the intermediate layer could be between 0.25 and 1.0 mm without affecting moisture retention in the rootzone mix above. Current USGA guidelines require the intermediate layer to contain at least 90% between 1& 4 mm. These results will make it possible to broaden the range of acceptable intermediate layer materials, thus reducing costs in some areas.

**Understanding the Hydrology of Green Construction Methods – Ohio State Univ.**

*Objectives:*

- Determine how profile design, rootzone mix, slope of green, drain spacing, profile depth, and irrigation practices affect water movement and the extent of perching in USGA and California method greens.
- Investigate how microbial activity in different rootzone materials changes over time.

*Treatments/Materials - Phase I*

- USGA vs. California profile design
- 8:2 sand/peat vs. 6:2:2 sand/compost/ soil
- 0% slope vs. 4% slope
- 4.5 inches per hour of simulated rainfall

*Conclusions to-date:*

- Putting green profile design, rootzone permeability and green slope all affect hydrologic behaviors.
- USGA green profile drained much more rapidly and more evenly than the CA profile.
- USGA green was much drier than CA profile after 48 hours.
- There was more lateral water movement in the rootzone mix of a sloped CA profile than a USGA green.
- Before construction, the 6-2-2 mix had 100-fold greater bacterial and fungal populations than the 8-2 mix.
- Three months after seeding, however, populations were only slightly higher in the 6-2-2 mix.

**Assessing Root Zone Mixes Under Two Environmental Conditions – Rutgers Univ.**

*Objectives:*

- Improve recommendations for sand particle size distribution and the depth of the root zone by consideration of the microenvironment.
- Evaluate composts as organic additives and inorganic products for root zone mixes compared to peat sources.
- Assess the potential of various root zone mixes to reduce management and resource inputs.
- Monitor the physical, chemical, and biological changes that occur in root zones as greens mature for understanding factors that contribute to the success or failure of greens.

*Conclusions to-date:*

- Environment (good vs. poor air circulation) had only a small effect on bentgrass establishment.
- Two finer sand materials (not meeting USGA guidelines) had a better rate of establishment than coarser sands, due to higher moisture retention.

- Amendment selection had a greater effect on establishment of bentgrass compared to sand particle size distribution.
- Generally, increasing the rate of amendment with soil and peats enhanced establishment. However, high-rate amendment treatments were no better than lower-rate treatments 40 days after seeding.

**Chemical and Physical Stability of Calcareous Sands Used for Green Construction –Washington State University**

*Objectives:*

- Determine if performance characteristics of putting greens decline as a result of weathering of calcareous sands.
- Determine the mechanism of this weathering and the subsequent performance decline.
- Provide guidelines to the USGA to determine the suitability of various calcareous sands for putting green construction.

*Conclusions to-date: (This investigation just began.)*

**New Technologies in Green Construction and Maintenance – North Carolina State University**

*Objectives:*

- Determine the physical properties of inorganic amendments alone and when mixed with three sand sizes for use in putting green profiles.
- Determine nutrient retention of inorganic and organically amended sand rootzone mixtures.
- Study the changes in soil physical properties and plant responses to sub-surface water evacuation and air-injection in five sand-based rootzones.

*Treatments/Materials*

- Fine, medium & coarse sand mixes
- Tested Ecolite, Greenschoice, Isolite, Profile, and sphagnum peat moss
- Straight sand, 10% amendment, 20% amendment and several other percentages with some amendments.
- 1) gravity, 2) vacuum, 3) vacuum + air injection

*Conclusions to-date: Amendments*

- Amendment addition increased total porosity, macro-porosity, and water retention.
- Sphagnum peat retained the most water and the most plant available water.
- Sphagnum peat had the most consistent effect on Ksat.
- $NH_4$-N leached: sand > Greenschoice=Isolite > peat > Profile > Ecolite
- Profile and Ecolite (20%) reduced $NH_4$-N leaching by 75 & 88% compared to straight sand.
- No amendment greatly reduced $NO_3$ leaching.

*Conclusions to-date: Air Injection/Evacuation*

- Mechanically induced drainage significantly decreased water content of rootzones.
- All rootzones had high (>18%) oxygen levels and low (<1.5%) $CO_2$ levels.

- Water evacuation/air injection had no effect on soil temperatures, which were very high (>88°), even at 4-8 inches below the surface.
- Drainage treatment had no effect on root mass.
- Total root mass decreased ~40% June-Sept.
- Pure sand consistently was lowest in root mass.
- Drainage treatment had no effect on turf quality.
- Pure sand had consistently lower turf quality than acceptable throughout 1998.

**Grow-in and Cultural Practice Inputs on USGA Greens and Their Microbial Communities – University of Nebraska**

*Objectives:*

- Determine how different grow-in and post-grow-in practices affect long-term hydrological, physical, chemical and microbiological changes.
- Develop guidelines as to when play can be allowed on new greens.

*Materials/Treatments:*

- 80/20 sand/peat vs. 80/5/15 sand/soil/peat
- Grow-in *Controlled* (3 lbs N/yr) vs. *Accelerated* (6 lbs N/yr)
- Microbial biomass was measured

*Conclusions to-date:*

- Higher N inputs produced faster turf cover, but did not translate to earlier opening for play because of environmental and disease damage to lush, immature turf.
- Soil-containing mix established more quickly.
- Soil-containing mix was harder.
- Water infiltration not was affected by mix type.
- Ball roll distance was 27% greater in *Controlled* vs. *Accelerated* greens in late fall.
- Grow-in treatments did not affect surface hardness.
- Microbial biomass was not affected by rootzone mix or grow-in procedure. Microbial biomass increased more than 200% from spring to fall, and decreased 40-60% as depth increased.

**Organic Matter Dynamics in the Surface Zone of USGA Greens – University of Georgia**

*Objectives:*

- Determine the effectiveness of summer cultivation practices and amendments on 1) rooting maintenance and viability during the summer, 2) shoot performance, 3) soil $O_2$ status, and 4) water infiltration.
- Develop an integrated year-round program for maximum root development and maintenance during stress periods.

*Conclusions to-date:*

- Percent organic matter by weight in the surface 1.25 inches ranged from10.1 to 10.2% for the untreated control. Core aeration with sufficient topdressing to fill the holes in March was the only treatment to reduce percent organic matter content (to 4.1 and 7.7%).

- High organic matter content in the surface 1.25 inches resulted in the following soil properties relative to USGA guidelines (in parentheses): total porosity of 75% (35-55%); aeration porosity of 17-22% (15-30%); capillary porosity of 54-57% (15-25%).
- At 17-26 days after cultivation, the most effective treatment for maintaining saturated hydraulic conductivity was the Hydro-Ject in the raised position, creating a ¼-inch hole.

**Effects of Fungicides on Microbial Communities in Putting Greens – Cornell Univ.**

*Objectives:*

- Investigate the effects of fungicide applications on non-target microbial populations in sand-based green profiles.
- Determine how these changes affect disease susceptibility, nitrogen cycling, and turf health.

*Treatments:*

- Applied the fungicides Daconil Ultrex, Chipco 26019, Subdue Maxx, Banner Maxx, Bayleton, Prostar and Sentinel at the maximum rate to individual plots throughout the season.
- Daconil and Prostar were applied at 14-day intervals; the others were applied at 21-day intervals.

*Conclusions to-date:*

- There were no effects whatsoever of even prolonged and extensive fungicide applications on non-target soil microbes by any method used.
- Likewise, there were no effects on total numbers of foliar microflora.
- However, foliar composition of fungi changed temporarily - filamentous fungi decreased while yeasts increased. Composition generally returned to normal within seven days.

**Bacterial Populations and Diversity in Sand-based Putting Greens – University of Florida, Clemson University, Auburn University**

*Objectives:*

- Determine what kinds of bacteria are found in new bentgrass and bermudagrass greens, and investigate where they come from.
- Investigate how organic matter, fumigation, nitrogen, and clay minerals affect bacterial populations.

*Methods and Treatments:*

- Tested for bacterial groups on sand, sphagnum peat, reed sedge peat, root zone mixes, and bermudagrass sprigs on arrival at site.
- Checked bacterial groups in sand peat mixes at 9 days (when plastic was removed) and 23 days after fumigation with a) methyl bromide or b) metam sodium.

*Conclusions to-date:*

- There are relatively large numbers and wide diversity of bacterial groups present in sand, peats, and sprigs prior to fumigation.
- Post-fumigation root zone mixes contained greater numbers within most bacterial groups than the unfumigated control.