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# LAYERS IN GOLF GREEN CONSTRUCTION

**For**


**United States Golf Association**
**Green Section Research**
**PO Box 2227**
**Stillwater**
**OK 74076**
**USA**


**By**


**STRI**
**Bingley, West Yorkshire, BD16 1AU**
**Telephone: 01274 565131**
**Fax: 01274 561891**
**E-mail: stri@rmplc.co.uk**


**Project No. 0015/3**

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EXECUTIVE SUMMARY

# LAYERS IN GOLF GREEN CONSTRUCTION

**Dr. Stephen Baker**
**Sports Turf Research Institute, United Kingdom**

**Cooperator: Daniel Binns**

## Goals

- *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 particle size criteria for the selection of intermediate layer and drainage layer materials.*

Two separate laboratory experiments have been established to examine particle migration into the underlying gravel and moisture distribution in the rootzone layer for a variety of golf green profiles.

In the first experiment a two-layered profile is considered with the rootzone layer directly overlying the drainage layer. Two rootzones have been used, one based on an 85/15 mix with medium-coarse sand and sphagnum peat, the other being a 70/30 mix of medium-coarse sand and the same peat. Ten gravels are included, five based on rounded material and five based on angular material, and these increase in size from a range where particle migration into the gravel should not occur to a size where there is a severe risk of downwards movement from the rootzone into the gravel. A total of 3000 mm of simulated rainfall is currently being applied at the rate of 100 mm per week. At the end of this period the gravel layer will be impregnated with an araldite resin containing fluorescent dye. When the resin has hardened, the impregnated material will be sectioned so that particle migration can be examined.

Vertical changes in moisture distribution in the rootzone layer will also be measured.

In the second part of the study columns simulating a three-layered USGA golf green profile have been established. The rootzone is based on an 80/20 sand/peat mix and the gravel is a predominantly 6-9 mm material conforming to USGA requirements. The intermediate layer is, however, varied to allow for increasing proportions of medium sand (0.25-0.5 mm) and coarse sand (0.5-1.0 mm) being added to the 1-4 mm grit that forms the intermediate layer. Moisture profiles will be assessed after saturation and 48 hours gravitational drainage to establish at what point the inclusion of finer material in the intermediate layer begins to affect the suspended water table in the rootzone layer.

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ANNUAL REPORT FOR THE USGA TURFGRASS RESEARCH COMMITTEE

# LAYERS IN GOLF GREEN CONSTRUCTION

By Dr. S.W. Baker & D.J. Binns
(The Sports Turf Research Institute, Bingley, West Yorkshire, BD16 1AU)

## INTRODUCTION

This report covers progress in the first year of the project on the effect of material selection for the intermediate and drainage layers on moisture distribution in the rootzone layer and on particle migration into the gravel. The work is being carried out in two parts, one dealing with two-layered constructions and the other involves three-layered constructions.

## PART 1. PARTICLE MIGRATION AND WATER RETENTION IN SITUATIONS WHERE THE ROOTZONE DIRECTLY OVERLIES THE GRAVEL LAYER

### Objectives

In the 1993 revision of the USGA *Recommendations for a Method of Putting Green Construction* an alternative to the three-layered construction profile (i.e. rootzone, intermediate layer, drainage layer) was permitted in which the rootzone could be laid directly on a fine gravel base. However, strict criteria were recommended to prevent the downwards migration of particles.

The objective of this project was to assess whether the bridging criteria that have been proposed can be relaxed to allow slightly coarser gravels to be used in the base layer. In addition, the experimental design allows moisture contents of the rootzone placed over different gravel bases to be assessed.

### Selection of materials

The experimental design allows for two contrasting rootzone materials to be placed in columns (Fig. 1) over ten different gravel base layers. The rootzone materials were based on two sand materials (Table 1) with the medium sand being mixed with 15% sphagnum peat and the medium-coarse sand being mixed with 30% sphagnum peat.

TABLE 1
Particle size analysis of the two rootzone sands.

| Category | Diameter mm | Medium-sand | Medium-coarse sand |
|---|---|---|---|
| Stones | >8.0 | 0 | 0 |
| Coarse gravel | 8.0-3.4 | 0 | 0 |
| Fine gravel | 3.4-2.0 | 0 | 0 |
| Very coarse sand | 2.0-1.0 | T | T |
| Coarse sand | 1.0-0.5 | 10 | 27 |
| Medium sand | 0.50-0.25 | 71 | 73 |
| Fine sand | 0.250-0.15 | 18 | T |
| Very fine sand | 0.15-0.053 | 1 | T |
| Silt + clay | <0.053 | T | T |

T = TRACE

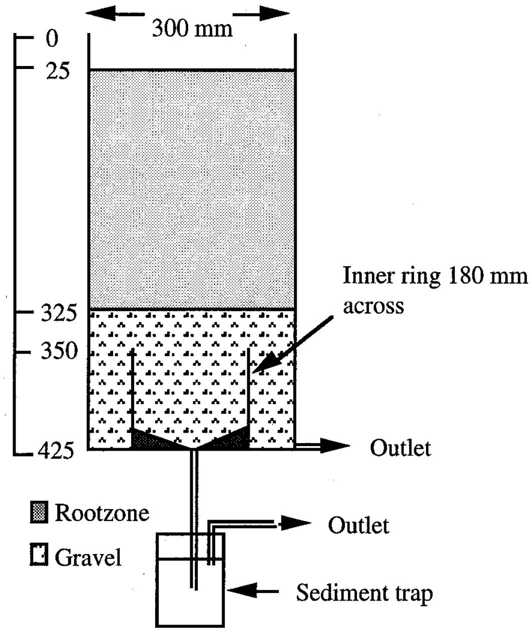


FIGURE 1. Cylinder arrangement to examine the effect of different gravels under the rootzone layer (depths shown are in mm).

The gravel materials encompassed a range of sizes with five angular gravels and five rounded gravels. These were prepared by sieving and blending material from several different gravel sources. Gravel size for the study was chosen on the basis of the bridging factor given by USGA Green Section Staff (1993), i.e.

$$D_{15} \text{ (gravel)} \leq 5 \times D_{85} \text{ (rootzone)} \qquad \text{Eq. 1}$$

The $D_{85}$ values for the medium and medium-coarse rootzones are 0.45 mm and 0.60 mm respectively. Under these circumstances, the maximum permissible $D_{15}$ value for the gravel using Eq. 1 should be 2.25 mm and 3.0 mm respectively. At the other extreme, preliminary laboratory tests using dry rootzone material suggested that both sands were likely to migrate once the $D_{15}$ of the underlying gravel exceeded 5 mm. Thus, five angular gravels and five rounded gravels were prepared having $D_{15}$ values based on equal steps in a logarithmic progression as follows: 2.2, 2.8, 3.5, 4.4 and 5.6 mm. The resulting bridging factors are given in Table 2.

TABLE 2
Bridging factors for the combination of two rootzones and five gravel sizes.
(Note: the 1993 revision of the USGA *Recommendations for a Method of Putting Green Construction* requires a value of ≤5).

| | Bridging factor | |
|---|---|---|
| $D_{15}$ of gravel (mm) | Medium rootzone $D_{85}$ = 0.45 mm | Medium-coarse rootzone $D_{85}$ = 0.60 mm |
| 2.2 | 4.9 | 3.7 |
| 2.8 | 6.2 | 4.7 |
| 3.5 | 7.8 | 5.8 |
| 4.4 | 9.8 | 7.3 |
| 5.6 | 12.4 | 9.3 |

**Current status of project**

Once suitable gravel materials had been obtained, the rootzone profiles were prepared between 15-21 July 1997 using air-dry sand and field-moist sand. Moisture contents were 2.4% w/w for the moist medium-coarse sand and 3.4% w/w for the moist medium sand. To date, approximately 1800 mm of the projected 3000 mm of water have been applied. Once the full 3000 mm of water have been added, equilibrium moisture contents will be determined and the gravel layer will be impregnated with resin containing a fluorescent dye so that particle migration can be assessed.

## PART 2. WATER RETENTION IN THE ROOTZONE LAYER OVER INTERMEDIATE LAYERS OF VARYING SIZE COMPOSITION

**Objectives**

In the *Recommendations for a Method of Putting Green Construction* (USGA Green Section Staff 1993) it is suggested that where three layers are used in the construction profile the gravel should have at least 80% of its particles between 2 mm and 12 mm and at least 65% between 6 mm and 9 mm. The recommendation for the intermediate layer was for 90% between 1 mm and 4 mm. In Britain, although 1-4 mm is the preferred range for an intermediate layer overlying a 5-10 mm gravel, up to 70% material below 1 mm can be used as long as it is greater than 0.25 mm (Baker 1990). This means that a greater range of construction materials is available. The main consequence of using finer grade intermediate layers is that the principal interface restricting downward percolation of water is likely to be that between the intermediate layer and the gravel base, rather than between the rootzone layer and the intermediate layer. As such, moisture content in the upper section of the rootzone may be slightly reduced when finer grade intermediate layers are used (Hunt & Baker 1996). The objective of the second part of the study was to examine the effects of increasing proportions of finer material between 0.25 mm and 1.0 mm in the intermediate layer on moisture retention in the rootzone layer.

**Material selection**

Details of the construction profile are given in Fig. 2. The rootzone is an 80/20 blend

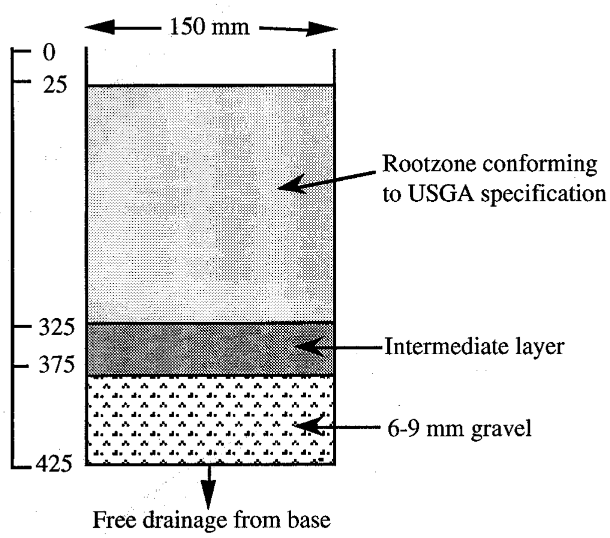


FIGURE 2. Cylinder arrangement to examine moisture retention in the profile with intermediate layers of varying composition (depths shown are in mm).

formed from a medium grade sand (Table 3) and sphagnum peat. Porosity values after compaction were:

| | | |
|---|---|---|
| Total porosity | = | 44% |
| Air-filled porosity* | = | 17% |
| Capillary porosity* | = | 27% |

* at 30 cm tension

TABLE 3
Particle size analysis of the sand used in the rootzone for the water retention study.

| Size (mm) | Analysis |
|---|---|
| 2.0-1.0 | T |
| 1.0-0.5 | 17 |
| 0.5-0.25 | 71 |
| 0.250-0.15 | 11 |
| 0.15-0.053 | 1 |
| <0.053 | T |

The grading of the intermediate layer varies and is based on the addition of increasing volumes of medium-coarse and coarse sand to a 1-4 mm grit (28% 3.35-2.0 mm, 69% 2.0-1.0 mm, 3% <1.0 mm). The particle size analyses of the resulting blends are given in Tables 4 and 5.

TABLE 4
Particle size distribution (%) of intermediate layer formed by blending 1-4 mm grit with medium-coarse sand.

| Size (mm) | Proportion of medium-coarse sand (%) | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 10 | 20 | 30 | 40 | 50 |
| 4.0-3.35 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3.35-2.0 | 28 | 25 | 23 | 20 | 17 | 14 |
| 2.0-1.0 | 69 | 62 | 55 | 48 | 41 | 35 |
| 1.0-0.5 | 3 | 10 | 16 | 23 | 30 | 36 |
| 0.5-0.25 | 0 | 3 | 6 | 9 | 12 | 15 |
| <0.25 | 0 | 0 | 0 | 0 | 0 | 0 |

TABLE 5
Particle size distribution (%) of intermediate layer formed by blending 1-4 mm grit with coarse sand.

| Size (mm) | Proportion of coarse sand (%) | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 10 | 20 | 30 | 40 | 50 |
| 4.0-3.35 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3.35-2.0 | 28 | 25 | 23 | 20 | 17 | 14 |
| 2.0-1.0 | 69 | 62 | 55 | 48 | 41 | 35 |
| 1.0-0.5 | 3 | 13 | 22 | 32 | 42 | 51 |
| 0.5-0.25 | 0 | 0 | 0 | 0 | 0 | 0 |
| <0.25 | 0 | 0 | 0 | 0 | 0 | 0 |

The gravel is a 6-9 mm material conforming to recommendations given by USGA Green Section Staff (1993). Thus, all the intermediate layer materials satisfy the bridging factor of:

$D_{15}$ (gravel) $\leq 5 \times D_{85}$ (intermediate layer)

On this basis there should be no problem of particle migration into the drainage layer.

**Current status of project**

The cylinders have been prepared and this phase of the work should be completed by March 1998.

**REFERENCES**

Baker, S.W. (1990). *Sands for Sports Turf Construction and Maintenance.* The Sports Turf Research Institute, Bingley, 71 pp.

Hunt, J.A. & Baker, S.W. (1996). The influence of rootzone depth and base construction on moisture retention profiles of sports turf rootzones. *J. Sports Turf Res. Inst.* **72**, 46-41.

USGA Green Section Staff (1993). USGA recommendations for a method of putting green construction. *USGA Green Section Record*, March/April 1993, 1-3.

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## Dr. Stephen W. Baker

Joined the Sports Turf Research Institute in 1980 after obtaining a B.Sc. in Geography at University College London (1974-77) and a Ph.D. from the University of Bristol (1977-80) for research on soil structure and water movement. At the STRI he originally held the position of Soil Physicist but is now Head of Soils and Sports Surface Science. Currently, he receives extensive funding from the governing bodies of golf, soccer, horse racing and cricket and has published over 150 scientific, technical and popular papers on aspects of sports turf management, including the book *Sands for Sports Turf Construction and Maintenance.* He currently leads the United Kingdom's delegation dealing with standardisation procedures for natural turf surfaces under the European Committee for Standardisation and was also a member of the Advisory Committee responsible for the 1993 revision of the USGA Green Construction Recommendations.

## Daniel J. Binns

Obtained his B.Sc. in Environmental Science from the University of Bradford (1992-96) during which time he worked at the Sports Turf Research Institute during his placement year. Since graduating in 1996 he has been employed as a research officer at the STRI and his work is concentrated on research for golf.

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**Estimated time spent on project**

| | |
|---|---|
| Dr. S.W. Baker (Head of Soils and Sports Surface Science) | 10% |
| Mr D.J. Binns (Research Officer) | 25% |
| Laboratory technician | 10% |

**Costs to date**

$1448 to cover cost of cylinders and stands and materials for testing under items b) and e) of the project budget.

The larger costs for the resin, hardener, fluorescent dye, sectioning and photographic work (given under items c) and d) will not occur until the second half of the project, although the resin is to be ordered next month.