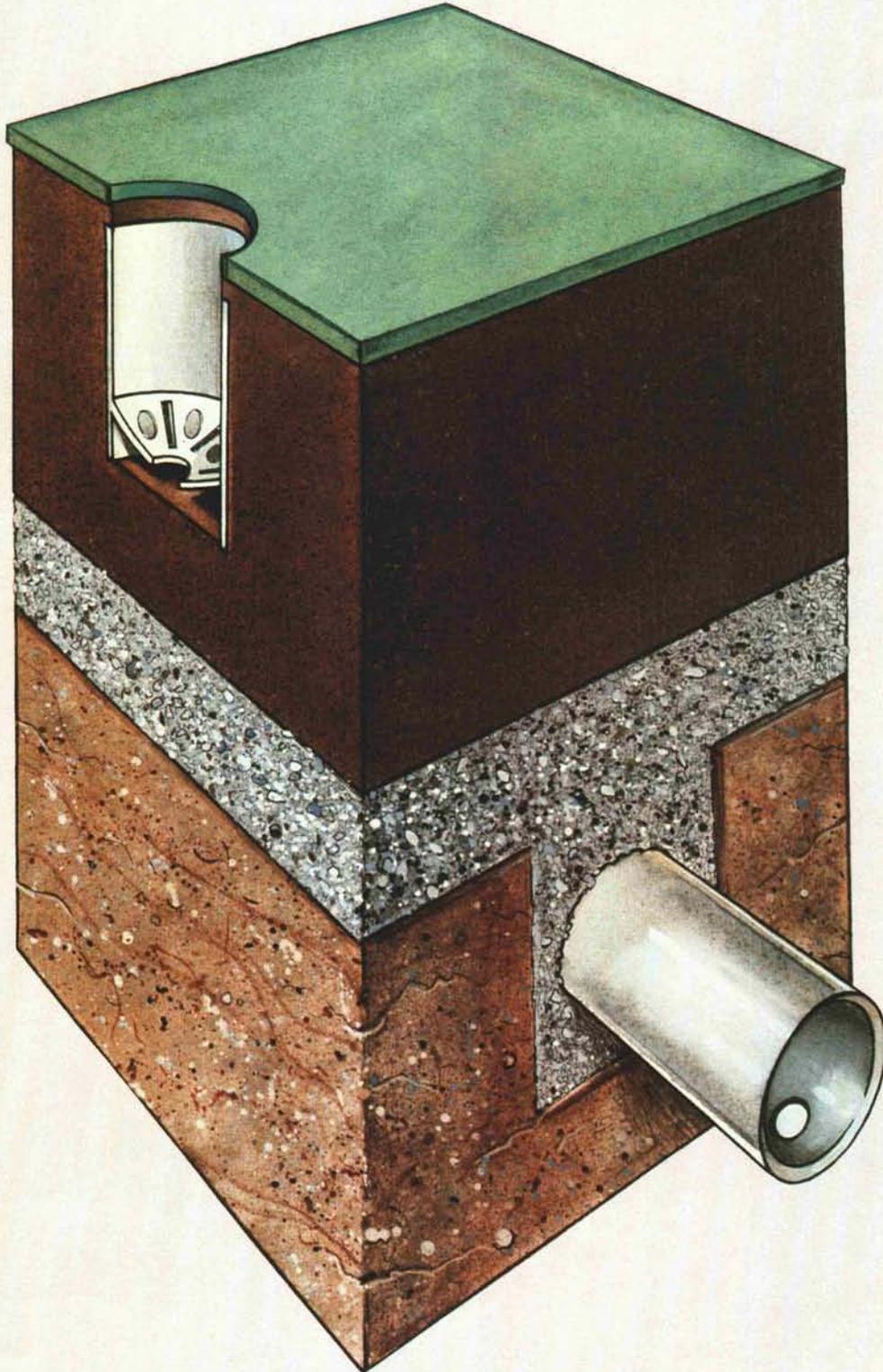


USGA Recommendations for Putting Green Construction

*Profile of a green built to USGA Recommendations with the intermediate layer (cover).
When the appropriate gravel is used, the intermediate layer can be eliminated (below).*



THE 1993 REVISION

USGA RECOMMENDATIONS FOR A METHOD OF PUTTING GREEN CONSTRUCTION

by the
USGA GREEN SECTION STAFF



Following is the 1993 revision of the USGA Recommendations for a Method of Putting Green Construction. These recommendations are based on a review of the scientific literature prepared by Dr. Norman W. Hummel, Jr., and advice from the Advisory Committee and Review Panel (see inside front cover).

Step 1. The Subgrade

The slope of the subgrade should conform to the general slope of the finished grade. The subgrade should be established approximately 16 inches (400 mm) below the proposed surface grade — 18 to 20 inches (450 to 500 mm) when an intermediate layer is necessary — and should be thoroughly compacted to prevent further settling. Water collecting depressions should be avoided.

If the subsoil is unstable, such as with an expanding clay, sand, or muck soil, geotextile fabrics may be used as a barrier between the subsoil and the gravel blanket. Install the fabric as outlined in Step 2.

Construct collar areas around the green to the same standards as the putting surface itself.

Step 2. Drainage

A subsurface drainage system is required in USGA greens. A pattern of drainage pipes should be designed so that the main line(s), with a minimum diameter of 4 inches (100 mm), is placed along the line of maximum fall. Four-inch (100 mm) diameter laterals shall run up and across the slope of the subgrade, allowing a natural fall to the main

line. Lateral lines shall be spaced not more than 15 feet (5 m) apart and extended to the perimeter of the green. Lateral lines should be placed in water-collecting depressions, should they exist. At the low end of the gradient, adjacent to the main line's exit from the green, drainage pipe should be placed along the perimeter of the green, extending to the ends of the first set of laterals. This will facilitate drainage of water that may accumulate at the low end of that drainage area.

Drainage design considerations should be given to disposal of drainage waters away from play areas, and to the laws regulating drainage water disposal.

PVC or corrugated plastic drainage pipe is preferred. Where such pipe is unavailable, clay or concrete tile is acceptable. Waffle drains or any tubing encased in a geotextile sleeve are not recommended.

Drainage trenches 6 inches (150 mm) wide and a minimum of 8 inches (200 mm) deep shall be cut into a thoroughly compacted subgrade so that drainage lines slope uniformly. Spoil from the trenches should be removed from the subgrade cavity, and the floor of the trench should be smooth and clean.

If a geotextile fabric is to be used as a barrier between an unstable subsoil and the gravel drainage blanket, it should be installed at this time. Under no circumstances should the fabric cover the drainage pipes or trenches.

A layer of gravel (see Step 3 for size recommendations) should be placed in the trench to a minimum depth of 1 inch (25 mm). It may be deeper, as necessary, to ensure a positive slope along the entire run of drainage lines. If cost is a consideration, gravel sized $\frac{1}{4}$ to 1 inch (6 to 25 mm) may be used for the drainage trench only.

All drainage pipe should be placed on the gravel bed in the trench, assuring a minimum positive slope of 0.5 percent. PVC drain pipe, if used, should be placed in the trench with the holes facing down. Backfill with additional gravel, taking care not to displace any of the drainage pipe.

Step 3. Gravel and Intermediate Layers

Place grade stakes at frequent intervals over the subgrade and mark them for the gravel drainage blanket layer, intermediate layer (if included), and root zone layer.

Table 1
PARTICLE SIZE DESCRIPTION OF GRAVEL
AND INTERMEDIATE LAYER MATERIALS

Material	Description
Gravel: Intermediate layer is used	Not more than 10% of the particles greater than ½" (12 mm) At least 65% of the particles between ¼" (6 mm) and ⅜" (9 mm) Not more than 10% of the particles less than 2 mm
Intermediate Layer Material	At least 90% of the particles between 1 mm and 4 mm

Table 2
SIZE RECOMMENDATIONS FOR GRAVEL
WHEN INTERMEDIATE LAYER IS NOT USED

<u>Performance Factors</u>	<u>Recommendation</u>
Bridging Factor	• $D_{15(\text{gravel})} \leq 5 \times D_{85(\text{root zone})}$
Permeability Factor	• $D_{15(\text{gravel})} \geq 5 \times D_{15(\text{root zone})}$
Uniformity Factors	• $D_{90(\text{gravel})} / D_{15(\text{gravel})} \leq 2.5$ • No particles greater than 12 mm • Not more than 10% less than 2 mm • Not more than 5% less than 1 mm

The entire subgrade then shall be covered with a layer of clean, washed, crushed stone or pea gravel to a minimum thickness of four inches (100 mm), conforming to the proposed final surface grade to a tolerance of ±1 inch.

Soft limestones, sandstones, or shales are not acceptable. Questionable materials should be tested for weathering stability using the sulfate soundness test (ASTM C-88). A loss of material greater than a 12% by weight is unacceptable.

The LA Abrasion test (ASTM C-131) should be performed on any materials suspected of having insufficient mechanical stability to withstand ordinary construction traffic. The value obtained using this procedure should not exceed 40. Soil engineering laboratories can provide this information.

The need for an intermediate layer is based on the particle size distribution of the root zone mix relative to that of the gravel. When properly sized gravel (see Table 1) is available, the intermediate layer is not necessary. If the properly sized gravel cannot be found, **an intermediate layer must be used.**

A. Selection and Placement of Materials When the Intermediate Layer Is Used

Table 1 describes the particle size requirements of the gravel and the intermediate layer material when the intermediate layer is required.

The intermediate layer shall be spread to a uniform thickness of two to four inches (50 to 100 mm) over the gravel drainage blanket (e.g., if a 3-inch depth is selected, the material shall be kept at that depth across the entire area), and the surface shall conform to the contours of the proposed finished grade.

B. Selection of Gravel When the Intermediate Layer Is Not Used

If an appropriate gravel can be identified (see Table 2), the intermediate layer need not be included in the construction of the green. In some instances, this can save a considerable amount of time and money.

Selection of this gravel is based on the particle size distribution of the root zone material. The architect and/or construction

superintendent must work closely with the soil testing laboratory in selecting the appropriate gravel. Either of the following two methods may be used:

1. Send samples of different gravel materials to the lab when submitting samples of components for the root zone mix. As a general guideline, look for gravel in the 2 mm to 6 mm range. The lab first will determine the best root zone mix, and then will test the gravel samples to determine if any meet the guidelines outlined below.

2. Submit samples of the components for the root zone mix, and ask the laboratory to provide a description, based on the root zone mix tests, of the particle size distribution required of the gravel. Use the description to locate one or more appropriate gravel materials, and submit them to the laboratory for confirmation.

Gravel meeting the criteria below will not require the intermediate layer. It is not necessary to understand the details of these recommendations; the key is to work closely with the soil testing laboratory in selecting the gravel. **Strict adherence to these criteria is imperative; failure to follow these guidelines could result in greens failure.**

The criteria are based on engineering principles which rely on the largest 15% of the root zone particles "bridging" with the smallest 15% of the gravel particles. Smaller voids are produced, and they prevent migration of root zone particles into the gravel yet maintain adequate permeability. The $D_{85(\text{root zone})}$ is defined as the particle diameter below which 85% of the soil particles (by weight) are smaller. The $D_{15(\text{gravel})}$ is defined as the particle diameter below which 15% of the gravel particles (by weight) are smaller.

• For **bridging** to occur, the $D_{15(\text{gravel})}$ must be less than or equal to five times the $D_{85(\text{root zone})}$.

• To maintain adequate **permeability** across the root zone/gravel interface, the $D_{15(\text{gravel})}$ shall be greater than or equal to five times the $D_{15(\text{root zone})}$.

• The gravel shall have a **uniformity coefficient** (Gravel D_{90} /Gravel D_{15}) of less than or equal to 2.5.

Furthermore, any gravel selected shall have 100% passing a ½" (12 mm) sieve and not more than 10% passing a No. 10 (2 mm) sieve, including not more than 5% passing a No. 18 (1 mm) sieve.

Step 4: The Root Zone Mixture

Sand Selection: The sand used in a USGA root zone mix shall be selected so that the particle size distribution of the **final root zone mixture** is as described in Table 3.

Soil Selection: If soil is used in the root zone mix, it shall have a minimum sand content of 60%, and a clay content of 5% to 20%. The final particle size distribution of the sand/soil/peat mix shall conform to that outlined in these recommendations, and meet the physical properties described herein.

Organic Matter Selection:

Peats—The most commonly used organic component is a peat. If selected, it shall have a minimum organic matter content of 85% by weight as determined by loss on ignition (ASTM D 2974-87 Method D).

Other organic sources — Organic sources such as rice hulls, finely ground bark, sawdust, or other organic waste products are acceptable if composted through a thermophilic stage, to a mesophilic stabilization phase, and with the approval of the soil physical testing laboratory. Composts shall be aged for at least one year. Furthermore, the root zone mix with compost as the organic amendment must meet the physical properties as defined in these recommendations.

Composts can vary not only with source, but also from batch to batch within a source. Extreme caution must be exercised when selecting a compost material. Unproven composts must be shown to be non-phytotoxic using a bentgrass or bermudagrass bioassay on the compost extract.

Inorganic and Other Amendments:

Inorganic amendments (other than sand), polyacrylamides, and reinforcement materials are not recommended at this time in USGA root zone mixes.

Physical Properties of the Root Zone Mix: The root zone mix shall have the properties summarized in Table 4, as tested by USGA protocol (proposed ASTM Standards).

Under the heading **Saturated Conductivity** in Table 4, **Normal range** refers to circumstances where normal conditions prevail for growing the desired turfgrass species. **Accelerated range** refers to conditions where water quality is poor, cool-season turfgrass species are being grown out of range of adaptation, or dust storms or high rainfall events are common.

Related Concerns

IT IS ABSOLUTELY ESSENTIAL TO MIX ALL ROOT ZONE COMPONENTS OFF-SITE. No valid justification can be made for on-site mixing, since a homogeneous mixture is essential to success.

A QUALITY CONTROL PROGRAM DURING CONSTRUCTION IS STRONGLY RECOMMENDED. Arrangements should be made with a competent laboratory to routinely check gravel and/or root zone samples brought to the construction site. It is imperative that these materials conform to the recommendations approved by the laboratory in all respects. Some tests can be performed on site with the proper equipment, including sand particle size distribution.

Care should be taken to avoid over-shredding the peat, since it may influence performance of the mix in the field. Peat should be moist during the mixing stage to ensure uniform mixing and to minimize peat and sand separation.

Fertilizer should be blended into the root zone mix. Lime, phosphorus, and potassium should be added based on a soil test recommendation. In lieu of a soil test, mix about ½ pound of 0-20-10 or an equivalent fertilizer per cubic yard of mix.

Table 3
PARTICLE SIZE DISTRIBUTION OF USGA ROOT ZONE MIX

<u>Name</u>	<u>Particle Diameter</u>	<u>Recommendation (by weight)</u>	
Fine Gravel	2.0 - 3.4 mm	Not more than 10% of the total particles in this range, including a maximum of 3% fine gravel (preferably none)	
Very coarse sand	1.0 - 2.0 mm		
Coarse sand	0.5 - 1.0 mm	Minimum of 60% of the particles must fall in this range	
Medium sand	0.25 - 0.50 mm		
Fine sand	0.15 - 0.25 mm	Not more than 20% of the particles may fall within this range	
Very fine sand	0.05 - 0.15 mm	Total particles in this range shall not exceed 10%	
Silt	0.002 - 0.05 mm		Not more than 5%
Clay	Less than 0.002 mm		Not more than 3%

Table 4
PHYSICAL PROPERTIES OF THE ROOT ZONE MIX

<u>Physical Property</u>	<u>Recommended Range</u>
Total Porosity	35% - 55%
Air-filled Porosity (at 40 cm tension)	15% - 30%
Capillary Porosity (at 40 cm tension)	15% - 25%
Saturated Conductivity	
Normal range:	6-12 inches/hr (15-30 cm/hr)
Accelerated range:	12-24 inches/hr (30-60 cm/hr)
Organic Matter Content (by weight)	1% - 5% (ideally 2% - 4%)

Step 5. Top Mix Covering, Placement, Smoothing, and Firming

The thoroughly mixed root zone material shall be placed on the green site and firmed to a uniform depth of 12 inches (300 mm), with a tolerance of ± ½ inch. Be sure that the mix is moist when spread to discourage migration into the gravel and to assist in firming.

Step 6. Seed Bed Preparation

Sterilization: Sterilization of the root zone mix by fumigation should be decided on a case by case basis, depending on regional factors. Fumigation always should be performed:

1. In areas prone to severe nematode problems.
2. In areas with severe weedy grass or nutsedge problems.
3. When root zone mixes contain unsterilized soil.

Check with your regional office of the USGA Green Section for more information and advice specific to your area.

Fertilization

Contact your regional USGA Green Section office for establishment fertilizer recommendations and grow-in procedures.