USGA®

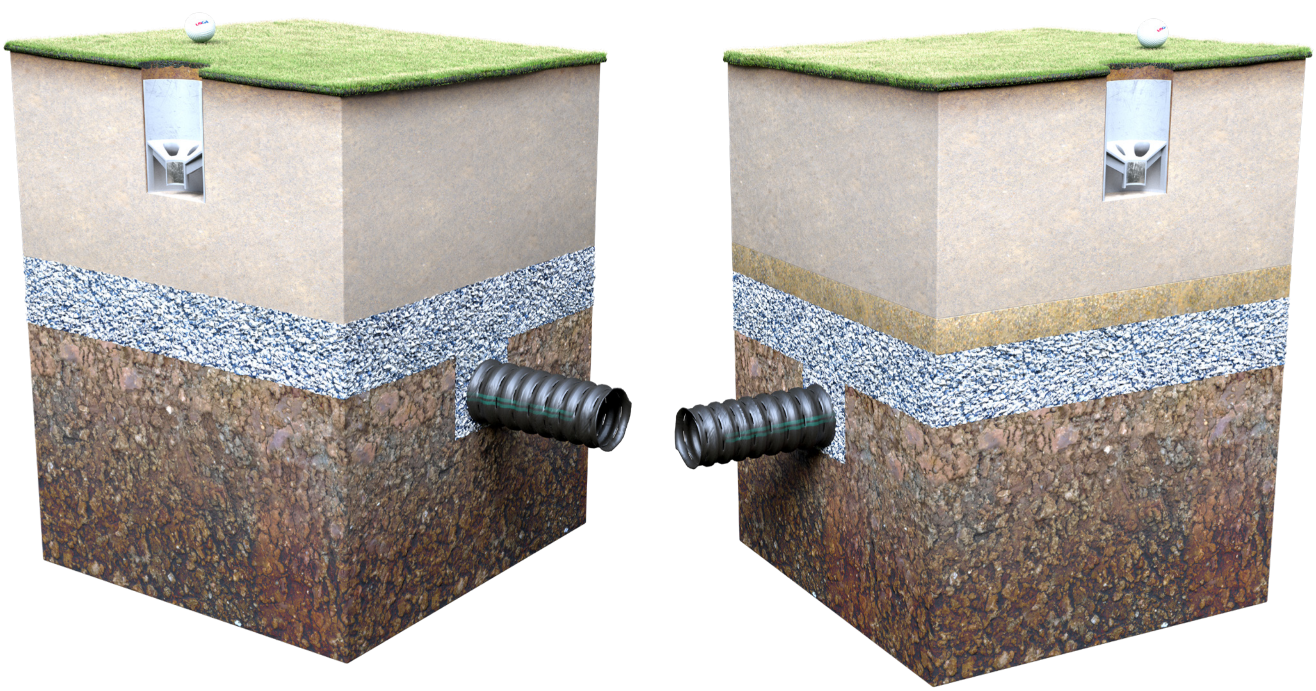
USGA RECOMMENDATIONS FOR A METHOD OF

Putting Green Construction

2018 REVISION

FOR NEARLY 60 YEARS the USGA recommendations for putting green construction have been the most widely used method of putting green construction throughout the United States and other parts of the world. When built and maintained properly, putting greens built in accordance to the USGA recommendations have provided consistently good results for golf courses over a period of many years. These recommendations are periodically reviewed and updated as a result of scientific research and as new techniques and materials are proven reliable.

This document specifically represents the USGA's recommendations for putting green construction. It does not include a discussion of construction techniques or methods. Additional documents are available from the USGA that describe construction methods, offering tips for success and providing guidance for putting green management.



STEP 1 | Assemble Your Team

Whether building putting greens on a new or existing site, it is important to have your project team lined up well before construction begins, including:

1. **Golf Course Architect:** The golf course architect is responsible for designing the putting greens and drafting the specifications with which a builder will be contractually obligated to comply.

COLLABORATION IS A CRITICAL PART OF SUCCESSFUL PUTTING GREEN CONSTRUCTION. KEY TEAM MEMBERS SHOULD BE IN CLOSE COMMUNICATION EARLY IN THE PLANNING PROCESS.

2. **Golf Course Superintendent:** The superintendent is an expert on maintaining putting greens under local conditions and should be consulted on many aspects of the construction process, especially when selecting materials and grass types.
3. **Golf Course Builder:** The golf course builder is a specialized contractor hired to complete substantial golf course construction and renovation projects. Often, golf course architects and superintendents have a list of contractors that they trust. A list of some golf course builders is also available through the Golf Course Builders Association of America.

STEP 2 | The Putting Green Cavity and Subgrade

The slope of the subgrade should conform to the general slope of the finished grade.

Excavate the putting green site to a depth approximately 16 inches (400 millimeters) below the proposed surface grade (18 to 20 inches or 450 to 500 mm when an intermediate layer is necessary).

Cavity walls should be 90 degrees to the cavity floor or steeply sloped. If the cavity walls are sloped, they should be sloped steeply enough to prevent significant differences in the depth of the rootzone mixture near the putting green perimeter. Include the collar area as part of the putting green cavity.

If fill soil is used to construct the putting green subgrade, the soil should be placed in 6-inch lifts and compacted to at least 90 percent of minimum standard Proctor density ASTM D698.

The subgrade should be shaped to avoid any water-collecting depressions and thoroughly compacted to prevent settling.

THE SUBGRADE MUST BE SMOOTH, FIRMLY COMPACTED AND FREE OF WATER-COLLECTING DEPRESSIONS.

If the subsoil is unstable – as may be the case with expanding clays, sand or highly organic soils – consult geotechnical engineers familiar with local soils for soil-stabilization recommendations. For more information about methods of stabilizing soils, please refer to the USGA publication "Building the USGA Putting Green: Tips for Success."

STEP 3 | Drainage

A subsurface drainage system is a requirement of putting greens built to USGA recommendations. The pattern of drainage pipes should be designed so that the main drains are placed along the lines of maximum fall. Install cleanout ports on the main drainage lines upstream and downstream from the putting green. These ports are created by extending risers from the main drain pipes to the surface. Attach a cap to the riser that is equipped with a stainless-steel insert or metal washer so that the riser can be easily located with a metal detector.

Install lateral drainage pipes at an angle across the slopes of the subgrade, allowing for a continuous slope of 0.5 percent or greater to the main drain. Space the lateral drains not more than 15 feet (5 meters) apart and extend them to the perimeter of the putting green cavity. Laterals should also be placed in water-collecting depressions if they exist.

At any low points where a main drain exits the putting green, place drainage pipe along the perimeter of the putting green cavity to facilitate the drainage of water that may accumulate along the cavity wall. Also install perimeter drains at any other low point along the edge of the putting green where water is likely to accumulate. It is important that the perimeter drains be installed immediately adjacent to the cavity wall. Perimeter drains installed even a short distance from the cavity wall may not adequately drain water from the putting green perimeter.

Drainage systems should be designed to remove excess water from playing areas in accordance to local and federal laws regulating drainage water disposal.

Drainage pipe shall be perforated polyvinyl chloride (PVC) or corrugated polyethylene (PE) pipe minimally conforming to ASTM D2729 or ASTM F667, respectively. The pipe shall have a minimum diameter of 4 inches (100 mm). Waffle drains, drain panels or any piping encased in geotextile sleeves are not recommended.

Drainage trenches shall be at least 6 inches (150 mm) wide, 8 inches (200 mm) deep and cut into thoroughly compacted subsoil so that the drainage pipes maintain a consistent 0.5-percent slope to the outlet. Remove all spoil from the trenches and smooth the trench floors. The subgrade floor also should be smooth and clean of all debris after trenching. If a geotextile fabric is to be used as a barrier between the subsoil and the gravel layer, it should be installed along the subgrade and in the drainage trenches once the cavity is completely clear of debris. Under no circumstances should geotextile fabric cover the drainage pipes or trenches.

Place a layer of gravel (Step 4) in the drainage trenches to a minimum depth of 1 inch (25 mm). The gravel in the trenches may be deeper than 1 inch to ensure that when the drainage pipes are installed they have a continuous slope of at least 0.5 percent toward the outlet.

Install all drainage pipes on top of a gravel layer in the drainage trenches. If using PVC drain pipe, install the pipe with the holes facing down. Pipe connections shall not impair the overall function of the pipeline. Backfill the trenches with additional gravel, taking care not to displace any of the drainage pipes or fittings. Ensure that there is gravel between the pipes and the trench walls.

LATERAL DRAINAGE PIPES SHOULD BE SPACED NOT MORE THAN 15 FEET APART AND HAVE A CONTINUOUS SLOPE OF 0.5 PERCENT OR GREATER TO THE MAIN DRAIN LINE.

As an alternative to round pipe placed in a trench, flat pipe may be placed directly on the prepared subgrade provided that the pipe conforms to ASTM D7001. The flat pipe should be a minimum of 12 inches (300 mm) wide and should not be covered with a geotextile sleeve. Staple or otherwise secure the flat pipe to the subgrade to prevent shifting or movement during construction. Rational combinations of round and flat pipe may be used within a putting green drainage system. All other guidelines for drainage system installation shall apply when utilizing flat drainage pipes, including the installation of perimeter drains and cleanouts. Encase and cover all drainage pipe with approved drainage gravel (Step 4).

STEP 4 | Gravel and Intermediate Layer

Installing a wicking barrier around the perimeter of a putting green is optional. However, if used, the wicking barrier should be installed along the cavity walls prior to installing the gravel layer. For more information about the use of a wicking barrier, refer to the USGA publication "Building the USGA Putting Green: Tips for Success."

After the drainage system is installed, place grade stakes at frequent intervals over the subgrade and mark them to indicate the depth of the gravel layer, intermediate layer (if included) and rootzone mixture. Cover the entire subgrade with a layer of clean, washed crushed stone or pea gravel to a minimum thickness of 4 inches (100 mm). The surface of the finished gravel layer should be 12 inches (300 mm) below the finished grade (14 to 16 inches or 350 to 400 mm if an intermediate layer is required) and shall conform to the proposed finished grade, plus or minus 1 inch.

Gravel composed of soft limestones, sandstones or shales is not acceptable. Questionable materials should be tested for stability using the Micro-Deval test ASTM D6928. A loss of material greater than 18 percent using this method is unacceptable.

There is evidence that placing low-pH rootzone mixtures over high-pH gravel materials such as limestone and dolomite contributes to the formation of iron oxide layers at the rootzone and gravel interface. These layers have been shown to impede drainage from the rootzone mixture to the gravel layer. If given the option, selecting a neutral-pH gravel is recommended.

An intermediate layer may be required between the gravel layer and rootzone mixture to prevent migration

THE GRAVEL LAYER SHOULD BE SPREAD TO A MINIMUM DEPTH OF 4 INCHES AND SHOULD MIRROR THE FINAL SURFACE OF THE PUTTING GREEN.

of the rootzone mixture into the gravel. The need for the intermediate layer is based on the particle size distribution of the rootzone mixture relative to the gravel. When properly sized gravel (Table 1) is available, the intermediate layer is not necessary.

If properly sized gravel cannot be sourced, an intermediate layer must be installed.

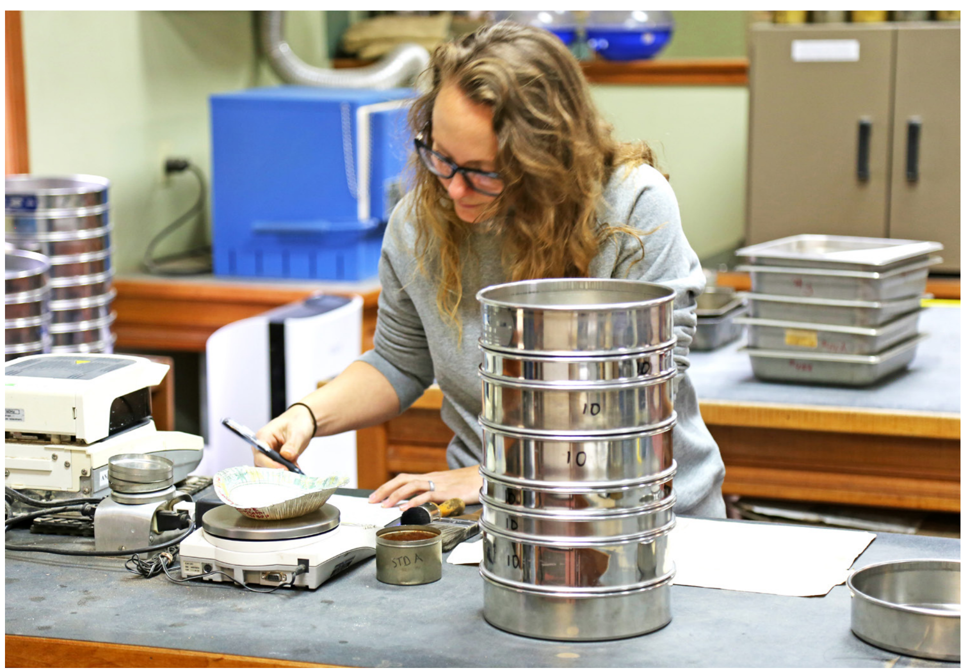
SELECTING GRAVEL TO EXCLUDE THE INTERMEDIATE LAYER:

The intermediate layer will not be required if the gravel used meets the recommendations in Table 1. Selecting the appropriately sized gravel depends on the particle size of the rootzone mixture. Therefore, the contractor, architect or superintendent must work closely with an A2LA Accredited Laboratory to select the appropriate gravel. Either of the following two procedures may be used:

- Send samples of different gravels to a lab along with the proposed rootzone mixture. As a general guideline, select gravel with a particle size diameter between 2 mm and 9.5 mm. After testing both the rootzone mixture and gravel, the lab will be able to determine which of the gravel samples will bridge with the rootzone mixture.
- Submit a sample of rootzone mixture to a lab and ask the lab to provide a description or specification of the gravel that would bridge with the rootzone mixture. Use this information to locate one or more acceptable gravel options and submit the gravels to the lab for confirmation.

The bridging factor, calculated by dividing the D15 of the gravel by the D85 of the rootzone, can be used to determine the need for an intermediate layer. The D15 of a gravel is the particle size diameter below which 15 percent of the gravel particles by weight are smaller. The D85 of a rootzone is the particle size diameter below which 85 percent of the rootzone particles by weight are smaller. If the bridging factor is less than or equal to 8, the rootzone and gravel can successfully be used in combination without the need for an intermediate layer because the rootzone is able to bridge the gaps between gravel particles. Gravel that meets the criteria in Table 1 will not require an intermediate layer.

Strict adherence to these criteria is imperative. Failure to follow these guidelines could result in compromised putting green performance or failure.



LABORATORY TESTING OF GRAVEL AND ROOTZONE MATERIALS IS NECESSARY TO ENSURE THE SUCCESS OF A PUTTING GREEN BUILT ACCORDING TO USGA RECOMMENDATIONS.

SELECTING AND PLACING MATERIALS WHEN THE INTERMEDIATE LAYER IS REQUIRED:

An intermediate layer will be required if the gravel and rootzone do not meet the bridging requirements in Table 1. The particle size requirements of the gravel and intermediate layer material are described in Table 2.

Spread the intermediate layer to a uniform thickness of 2 to 4 inches (50 to 100 mm) over the gravel layer– e.g., if a 3-inch depth (75mm) is selected, the intermediate layer material shall be spread to a consistent 3-inch depth across the entire surface of the gravel layer. The surface of the intermediate layer should conform to the contours of the proposed finish grade.

TABLE 1. Rootzone and Gravel Performance Factors When Intermediate Layer is Not Required

Bridging Factor	$\frac{\text{D15 (gravel)}}{\text{D85 (rootzone)}}$	≤ 8
Permeability Factor	$\frac{\text{D15 (gravel)}}{\text{D15 (rootzone)}}$	≥ 5
Uniformity Factors	$\frac{\text{D90 (gravel)}}{\text{D15 (gravel)}}$	≤ 3
	100% passing a 12-mm screen ≤ 10% passing a 2-mm screen ≤ 5% passing a 1-mm screen	

TABLE 2. Particle Size Recommendations When the Intermediate Layer is Used

Gravel Layer	≤ 10% larger than 0.5 inch (12.7 mm) ≥ 65% between 0.250 inch (6.4 mm) and 0.375 inch (9.5 mm) ≤ 10% smaller than 2 mm
Intermediate Layer	≥ 90% between 1 mm and 4 mm

STEP 5 | The Rootzone Mixture

SAND SELECTION:

Putting greens built to USGA recommendations are sand-based systems – i.e., sand is the primary component of the growing medium or rootzone mixture. Sand is defined as any particle between 0.05 and 2 mm in diameter. It is important to note that sands differ in their mineral makeup based on the parent rock material from which they are derived. Therefore, the mineral makeup of sands differs across geographic areas.

Quartz sands that are predominately silicon dioxide (SiO_2) are chemically inert and therefore resistant to chemical decomposition or change over time. Highly pure quartz sands are rare, and availability is limited to just a few areas in the United States. Many, if not most, of the sands used for putting green construction are a composite of silica minerals including quartz, feldspars and other minerals.

In some cases, sand may contain calcium carbonate ($CaCO_3$) – e.g., calcite or aragonite – or calcium magnesium carbonate ($CaMg(CO_3)_2$) – i.e., dolomite. Since sands have little ability to resist changes in pH, even small amounts of these minerals will increase the pH of a sand. Calcareous sand is a blanket term describing high-pH sands regardless of the amount of calcium or magnesium carbonate that may be present. Aside from the high pH, the long-term stability of calcium and calcium magnesium carbonate is questionable, especially where acidifying fertilizers or acidic irrigation water is used. While it would be best to minimize the amount of calcium and magnesium carbonates in rootzone sands, it is important to understand that calcareous sands have been used for the construction of many putting greens that have performed well for many years. However, sands that are predominately calcium carbonate – e.g., coral sands – are not recommended.

MATERIALS TESTING REQUIRES SPECIALIZED EQUIPMENT AND SKILLS AND SHOULD ONLY BE PERFORMED BY AN ACCREDITED LABORATORY.

Sand selection, especially with regard to particle size, is critical to the successful performance of a putting green. Sand particle size will have a profound influence on putting green performance; affecting factors such as water retention, drainage and firmness. Fine sands will have greater water retention than coarse sands, so less organic or inorganic amendment can be used to achieve adequate capillary porosity. Coarse sands retain little water and, therefore, often must be amended to increase capillary porosity.

Sands that are too uniform may lack sufficient particle packing to form a stable or firm surface. To quantify particle size uniformity, the USGA recommends sands have a coefficient of uniformity (Cu) within the ranges in Table 3. The lower the Cu, the more uniform the particle size and the greater the risk for unstable or soft putting greens. Conversely, sands with high Cu values will pack, potentially providing firmer surfaces. Sands with excessively high Cu values may pack too tightly, adversely affecting drainage and rooting.

Sand particle shape also influences stability. Rounded sands may require a higher Cu to provide a firm surface while more angular sands may provide adequate stability with a lower Cu.

The USGA recommends selecting sands for putting green rootzones so that the particle size distribution of the final rootzone mixture conforms to the description in Table 3. The sand shall preferably be a naturally occurring sand not a manufactured sand produced by crushing rock.

SOIL SELECTION:

If soil is used in the rootzone mixture, it shall preferably be a screened, 0.5-inch (12.5 mm) sandy loam soil having a minimum sand content of 60 percent and a clay content of 5 to 20 percent. The particle size distribution of the final sand/soil/peat mixture shall conform to these recommendations and the physical properties described herein. Be aware that soil may be a source of weed seed, possibly necessitating fumigation of the rootzone mixture.

TABLE 3. Recommended Particle Size Distribution for a Putting Green Rootzone Mixture

PARTICLE	DIAMETER	SIEVE	% BY WEIGHT
Coarse gravel	> 4 mm	No. 5	0%
Fine gravel	2.0 – 3.4 mm	No. 10	≤ 3% gravel
Very coarse sand	1 – 2 mm	No. 18	≤ 10% combined in this range
Coarse sand	0.5 – 1.0 mm	No. 35	≥ 60% of the particles in this range
Medium sand	0.25 – 0.5 mm	No. 60	
Fine sand	0.15 – 0.25 mm	No. 100	≤ 20%
Very fine sand	0.05 – 0.15 mm	No. 270	≤ 5%
Silt	0.002 – 0.05 mm		≤ 5%
Clay	< 0.002 mm		≤ 3%
Total fines	Very fine sand + silt + clay		≤ 10% combined
Coefficient of Uniformity (D60/D10)		1.8 - 3.5	Rootzone mixtures with peat
		2.0 - 3.5	Rootzone mixtures with inorganic amendments
		2.0 - 3.5	Pure sand rootzone mixtures

ORGANIC MATTER SELECTION:

Organic matter, usually in the form of peat, can be added to sand to increase water and nutrient retention compared to sand alone. Organic matter should be incorporated throughout the full 12-inch (300 mm) rootzone depth. Incorporate the organic matter as described in the Rootzone Mixture Blending section.

PEATS: The most common organic amendment used in rootzone mixtures is peat. The two most common types of peat are sphagnum moss peat and reed sedge peat. Refer to the USGA publication "Building the USGA Putting Green: Tips for Success" for more information on the characteristics of peat types. The peat used in the rootzone mixture shall have an organic matter content of at least 85 percent by weight as determined by loss on ignition ASTM D2974, Method C. In addition, the peat shall be screened to no larger than 0.25 inches (6.4 mm).

COMPOSTS: Compost may be considered as an organic amendment if the product is composted through the thermophilic stage to the mesophilic maturation stage. The compost should be aged for one year to assure that it is fully mature. In addition, a rootzone mixture amended with compost must meet the physical performance parameters outlined in these recommendations.

Composts can vary not only by source, but also from batch to batch within a source. Extreme caution must be exercised when using compost in rootzone mixtures. Any compost selected for a rootzone mixture amendment shall meet the following parameters:

- 95 – 100% passing a 0.25-inch screen (6.4 mm)
- Organic matter content ≥ 50% as determined by ASTM D2974, Method C
- Moisture content between 30% – 60%
- Carbon to nitrogen ratio between 15:1 – 30:1
- Solvita Compost Maturity Index of 7 – 8
- Electrical conductivity ≤ 6 dS/m
- pH between 4 – 8
- Proven to be non-phytotoxic
- Meet or exceed ceiling concentrations and pollutant concentrations as specified by US EPA Class A standard, 40 CFR § 503.13, Tables 1 and 3, respectively

Any test report on compost must be less than one month old and represent the actual compost that will be used to amend the rootzone mixture.

INORGANIC AND OTHER AMENDMENTS:

Porous inorganic amendments such as calcined diatomites, porous ceramics – e.g., calcined clays – and zeolites may be used in place of or in addition to peat in a rootzone mixture. However, the particle size of the amendment and the performance characteristics of the rootzone mixture must meet the recommendations in Tables 3 and 4. Users of these products should be aware that there are considerable differences among products. Porous inorganic amendments should be incorporated throughout the full 12-inch (300 mm) depth of the rootzone mixture. Polyacrylamides and soil-reinforcement products are not recommended.

Other amendments such as humates, biochar, seaweed products, vermiculture byproducts and similar products are sometimes used to amend rootzone mixtures. While some may view these products as adding value, they are not a replacement for peat or porous inorganic amendments. Since these products may influence the physical properties of a rootzone mixture, it is important that lab testing include these products at anticipated rates.

PHYSICAL PROPERTIES OF A ROOTZONE MIXTURE:

A rootzone mixture shall have physical properties tested per ASTM F1815. Sometimes referred to as performance parameters, these properties include total porosity, air-filled porosity, capillary porosity and saturated hydraulic conductivity – i.e., infiltration rate. Rootzone mixtures shall have physical properties meeting those listed in Table 4.

While it is an important property, arguably too much emphasis has been placed on infiltration rate (Ksat) in the past. Although rootzone mixtures with Ksat values below 6 inches per hour have a high risk of experiencing drainage problems in the field, a high Ksat value does not necessarily mean a rootzone mixture will be droughty. Different rootzone amendments have different water-retention characteristics that can influence Ksat. For example, adding small amounts of soil to a rootzone mixture will likely reduce Ksat without significantly increasing water retention, while incorporating inorganic amendments will increase water retention often without decreasing Ksat. The bottom line: if the capillary porosity – i.e., water retention – of a rootzone mixture is within the recommended range, the rootzone mixture should not be excessively droughty even if the Ksat is high. The USGA publication "Building the USGA Putting Green: Tips for Success" provides a more in-depth discussion on this topic and information on how to learn more about the water-retention characteristics of rootzone mixtures.

TABLE 4. Physical Properties of a Rootzone Mixture

PHYSICAL PROPERTY	RECOMMENDED RANGE
Total Porosity	35%–55%
Air-filled Porosity	15%–30%
Capillary Porosity	15%–25%
Saturated Hydraulic Conductivity (Ksat)	≥ 6 inches/hour (150 mm/hr.)

Many rootzone mixture suppliers have off-the-shelf rootzone mixtures that are routinely produced for golf course projects. If that is not the case, an accredited lab can help you develop or design a rootzone mixture that meets your exact specifications. Either way, it is important that comprehensive performance testing be conducted on a sample of the final rootzone mixture to ensure that it meets the properties listed in Table 4. Do not rely on reports from other projects or earlier stages of rootzone blending because sand characteristics and performance can change over time. The approved rootzone mixture will serve as the baseline against which all quality control samples should be compared.

QUALITY CONTROL TESTING:

Once the gravel and rootzone mixture has been approved, it is important that samples of each be tested prior to delivery to ensure consistency throughout the project. Make arrangements with an A2LA Accredited Laboratory to routinely check the gravel and rootzone mixture during production and blending. It is recommended that gravel be tested every 500 tons. Rootzone mixture should be tested to determine at least particle size and organic matter every 500 to 1,000 tons. It is recommended to conduct full performance testing if there are any discrepancies in the particle size or organic matter content. Rootzone mixture samples should be collected at the production facility for quality control testing.

THE FINAL PRODUCT.

Variability in the raw materials used in a rootzone mixture is normal over time. If the baseline rootzone mixture was tested several weeks or months before the actual rootzone mixture is produced for a project, it is recommended that full performance testing be repeated on the first 200 tons of rootzone mixture. If the results of that testing are acceptable, the new results should serve as the baseline production sample for the project.

ROOTZONE MIXTURE SAMPLES SHOULD BE COLLECTED AT THE PRODUCTION FACILITY FOR QUALITY CONTROL TESTING.

When collecting rootzone mixture samples for quality control testing, it is recommended that a golf facility representative be present or collect the sample themselves and ship it to the lab.

Quality control testing is only as good as how representative a sample is of the rootzone mixture in the field. It is imperative that good samples be taken in the field. The USGA publication **"Quality Control Sampling of Sand and Rootzone Mixture Stockpiles"** offers a detailed pictorial on proper sampling techniques. Table 5 lists the maximum amount of variation that should be tolerated for key test parameters in quality control samples.

If a sample deviates in one or more parameters, it is important for all parties involved to discuss and decide if the deviation is significant enough to reject the batch of rootzone mixture. A lab or soils consultant with experience in reviewing quality control data may be able to offer assistance in this review. Refer to the USGA publication "Building the USGA Putting Green: Tips for Success" for more information about this topic.

ROOTZONE MIXTURE BLENDING:

It is essential to blend all rootzone components with mechanical blending equipment that is specially designed to produce a consistent rootzone mixture. Methods that should NOT be used include loader-bucket flipping, farm implement mixing or on-site rototilling in a putting green cavity.

If soil tests determine that a rootzone mixture has a lime requirement, the lime shall be thoroughly blended into the rootzone mixture at the same time as any other organic or inorganic amendments.

TABLE 5. USGA Confidence Intervals for Quality Control Testing

TEST PARAMETER	USGA CONFIDENCE INTERVAL(%)
Fine gravel	50
Very coarse sand	50
Coarse sand	15
Medium sand	15
Fine sand	15
Very fine sand	30
Total porosity	10
Air-filled porosity	15
Capillary porosity	15
Saturated hydraulic conductivity	25
[1] Percent organic matter	± 0.2 for mixes with > 1% OM ± 0.15 for mixes with ≤ 1% OM

[1] The confidence interval for organic matter is an absolute value, not a percentage of the target organic matter content. For example, a rootzone mixture with a target organic matter content of 0.7 percent would have an acceptable range of 0.55 to 0.85 percent.

Avoid excessive handling of peat and the blended rootzone mixture. Sand will abrade or grind fragile peat fibers, potentially affecting the physical characteristics of a rootzone mixture. Excessive handling also includes re-blending a rejected rootzone mixture.

The peat and sand should be moist during the blending process to ensure uniform mixing and to minimize segregation of the peat and sand.

STEP 6 | Rootzone Installation

Place the rootzone mixture into the putting green cavity by dumping it on the edge and spreading it across the gravel or intermediate layer with appropriate equipment. Under no circumstance should trucks be allowed to drive onto placed rootzone mixture. The rootzone mixture should be spread and uniformly firmed to a 12-inch (300 mm) depth with a tolerance of plus or minus 1 inch (25 mm). Moistening the rootzone mixture during spreading will assist with firming and prevents segregation of the peat and sand. Perform light power tamping along the edges of the putting green and over any areas where grade stakes were located because these areas may not receive the same amount of traffic and firming during the spreading process.

Heavy watering after placement will help the rootzone mixture settle. Check grades and add or remove rootzone mixture as necessary to achieve the final putting green grade.

IT IS ESSENTIAL TO BLEND ALL ROOTZONE COMPONENTS WITH MECHANICAL BLENDING EQUIPMENT THAT IS SPECIFICALLY DESIGNED TO PRODUCE A CONSISTENT MIXTURE.

STEP 7 | Pre-Plant Preparation and Establishment

USGA-recommended sand-based rootzone mixtures typically have low cation exchange capacities (CEC), so nutrient retention will be low. Pre-plant fertilizer will facilitate turf establishment. Apply fertilizer amendments as recommended by a soil testing lab or soils consultant. Work any pre-plant amendments to a depth of 2 inches prior to final smoothing.

If necessary, fumigate the rootzone mixture after the final grade is achieved. Fumigation should be considered:

- In areas prone to severe nematode problems
- In areas with severe weed problems

Putting greens can be established from seed, sod or sprigs. Refer to the USGA publication "Building the USGA Putting Green: Tips for Success" for suggestions on proper establishment techniques.

If sod is to be used for planting, it should ideally be grown on a rootzone mixture that is identical or very similar to the rootzone mixture used for the project. If that is not possible, washed sod is recommended. In no case is it acceptable to place unwashed sod grown on loam or fine-textured soil above a sand-based rootzone mixture.

THE ROOTZONE MIXTURE SHOULD BE SPREAD AND UNIFORMLY FIRMED TO A 12-INCH DEPTH WITH A TOLERANCE OF PLUS OR MINUS 1 INCH.

STEP 8 | Grow In

For suggestions on establishing a new or renovated putting green, contact your regional USGA Agronomist and refer to the USGA publication "Building the USGA Putting Green: Tips For Success."

APPENDIX 1

TEST METHODS AND MATERIAL SPECIFICATIONS

All of the methods and material specifications listed below are published by the American Society for Testing and Materials (ASTM). The standards can be acquired at www.ASTM.org. Since the standards are updated regularly, we recommend that you check for the most current standard.

ASTM D698. Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort

ASTM D6928. Standard Test Method for Resistance of Coarse Aggregates to Degradation by Abrasion in the Micro-Deval Apparatus

ASTM C136. Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

ASTM D75. Standard Practice for Sampling Aggregates

ASTM D854. Standard Test Method for Specific Gravity of Soil Solids by Water Pycnometer

ASTM D5550. Standard Test Method for Specific Gravity of Soil Solids by Gas Pycnometer

ASTM F1815. Standard Test Methods for Saturated Hydraulic Conductivity, Water Retention, Porosity, and Bulk Density of Athletic Field Rootzone Mixes

ASTM F1632. Standard Test Method for Particle Size Analysis and Sand Shape Grading of Golf Course Putting Greens and Sports Field Rootzone Mixes

ASTM F1647. Standard Test Method for Organic Matter Content of Athletic Field Rootzone Mixes

ASTM D2974. Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils

ASTM D2976. Standard Test Method for pH of Peat Materials

ASTM D4972. Standard Test Method for pH of Soils

ASTM D2729. Standard Specification for Polyvinyl chloride (PVC) Sewer Pipe and Fittings

ASTM F667. Standard Specification for Corrugated Polyethylene (PE) Pipe and Fittings

ASTM D7001. Standard Specification for Geocomposites for Pavement Edge Drains and Other High-Flow Applications

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