Modifying Rootzones with Sand

Where's the Economic and Agronomic Breakpoint?

by Dave Minner

Successfully built sand based fields can be very expensive. Just what are the agronomic and financial breakpoints of using sand in the rootzone? Can we use less sand, reduce the cost and still have a successful field? Can we take the existing soil, mix it with the proper amount of sand and produce an improved field?

In any field construction or modification, ultimately you want to spend your money wisely and be assured the finished product meets your expectations.

Start by asking yourself the right questions: How have your current fields performed, what has failed, what has worked well and what do you want changed? Do you have the budget, equipment and personnel to care for a new field system? How much traffic and what type of activities are planned for the field? What is your expectation for appearance and playing conditions? Do you want the fastest draining field possible or are you willing to cancel events or tolerate some excess moisture during high-rainfall events? Most field concerns involve drainage, compaction and surface stability

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Why sand?

Nearly all professional and collegiate football fields newly constructed or rebuilt in the last 10 years have utilized some type of rapid drainage sand based system. Sands are used because they are less likely to compact and puddle because of large pores in the rootzone media. Compared to "soil-type" fields, water rapidly enters a sand based field and quickly moves throughout the rootzone profile. From there, various types of under drainage pipe systems are used to move water away from the bottom of the porous rootzone.

Sand is divided into five different classes based on particle size: coarse, very coarse, medium, fine and very fine. The gradation of sand usually is specified as a guide to allow location of a material that can be mixed with soil, peat or inorganic amendments to provide specific performance criteria. Particle size analysis alone is not enough information to predict how a rootzone sand mix will perform. Other important performance criteria that require testing include aeration, porosity, capillary porosity, organic matter, bulk density, coefficient of uniformity and water infiltration rate.

The USGA concept was developed in the 1960s for golf green construction. It was modified in the 1990s and today stands as the most widely used concept for construction of sand based golf greens and athletic fields. In general, a 12-inch rootzone (usually a mixture of graded sand and peat) is placed over a 4-inch layer of 3/8-inch pea gravel. A network of trenched drains (perforated drain pipe in gravel on 20-foot centers) is connected to the bottom of the pea gravel layer. This unique system of layers creates a perched water table that stores sufficient water for plant growth, but also allows for rapid water infiltration and subsurface drainage. There are specific guidelines for selection of the sand, peat and gravel materials. Testing and quality control are a critical part of sand based systems.

Construction materials vary at different locations. The physical and chemical properties of local materials must be suitable for agronomic use. An accurate bid for construction cannot be submitted until sand and gravel

Table A—Examples of rootzone mixtures for athletic fields.

	Sieve Mesh	Dia. (mm)	USGA Specification % Retained	Football Field Specification % Retained	Example A USGA Clean Sand Mixed with Peat	Example B USGA Clean Sand Mixed with Soil	Example C Clean Sand Mixed Off-Site with Soil	Example D Sand Pad	Example E Till Coarse Sand into Soil on Site	Example F Native Soil
Gravel	10	2.0	≤3 Gravel	Max. 10	1	0	2	0	0	0
Very Coarse	18	1.0	≤10 Combined	Max. 10	8	8	3	10	20	0
Coarse	35	0.5	Min. 60	Min. 50	28	29	25	25	30	0
Medium	60	0.25	Min. 60	Min. 50	47	42	33	29	20	5
Fine	100	0.15	Max. 20	Max. 25	12	14	22	25	5	12
Very Fine	270	0.05	Max. 5	Max. 10	3	1	5	5	5	13
Sand					99	94	90	94	80	30
Silt		0.002	Max. 5	Max. 9	0.4	4	5	3	10	41
Clay		<0.002	Max. 3	Max. 6	0.6	2	5	3	10	29
Ksat Infiltration Rate (in/hr)			Normal: 6-12 in/hr; Accelerated: 12-24 in/hr	6-15 in/hr	21	15	9	12	1	0.1
Rootzone Depth			12"		12"	12"	12"	6"	6"	
Gravel Blanket Depth			4"		4"	4"	4"	None	None	
Drain Spacing			20'		20'	20'	20'	8'		
Est. Cost per 80,000 sq. ft. Football Field					$400,000—$600,000	$400,000—$600,000	$400,000—$600,000	$200,000—$300,000	$35,000—$110,000	

materials have been qualified since the cost of these materials can range from $15 to $50 per ton. The material cost for and average field (8,000 tons of sand and gravel) can range from $120,000 to $360,000.

I start with USGA specifications when recommending rapid drainage sand based fields. They have a proven track

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record in both the agronomic and playability arena. Failures with the USGA system usually are not related to construction or design, but are the results of poor planning. Stability is always a concern with sand systems. The footing required for baseball and soccer is less than that for football. If the field goes through one complete football playing season without the need for resodding it is unlikely that surface stability will be a problem. Stability problems that occur in the first season are often the result of insufficient grow-in time.

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Fields that must be game ready in August should be sodded with cool season grasses by April 1. Preferred is fall/winter sodding during the previous year to allow a full season of spring rooting and possibly some winter rooting to insure stability of sand-based fields. Cool season sod installed after mid-May generally produces a weak root system during the summer that is simply insufficient to hold the field together during football activities. When replacing an old field with a new sand-based system have the starting construction date coincide with the last game in the fall. When given proper advanced planning an organized construction company can build the field in 25 to 45 days, allowing for an early winter sodding. Plan the sodding date first and then plan the rest of the project.

There currently is no organization that specifically deals with sport field agronomic specifications. The American Society of Testing and Materials (ASTM) has many standards for testing materials and individual components that make up a field system. However, there are no standards for athletic field rootzones at this time. Fortunately, soil testing labs, turf and soil researchers at universities and construction and design companies have been working together to develop improved fields. Table A provides some of the basic field types and materials that are being used. They represent a wide range in cost and thus provide insight when determining how much to spend on a field—or where's the financial breakpoint. The estimated costs are provided to give a relative comparison among different field types. They may not represent the actual cost of building a similar type field in your area.

How much silt and clay?

Recently there has been a trend to maximize the amount of silt and clay in the sand rootzone without decreasing water infiltration too greatly. The USGA specification allows for a maximum of 8 percent silt and clay. Some athletic field mixes maintain adequate water infiltration rates (6 to 12 inches per hour) with 9 to 13 percent silt and clay. As the field matures, properly selecting topdressing materials and providing deep and conventional coring on a routine basis can maintain these infiltration rates. Many golf greens are built with accelerated infiltration rates (15 to 25 inches per hour) because USGA research has shown that as the greens mature the infiltration rates can drop as much as 10 inches per hour, due to organic build up in the rootzone. In my experience, this is less of a concern in sport fields if aerification, core removal and topdressing are carefully monitored. A sand-based field with an infiltration rate of 6 inches per hour and 10 percent silt/clay will grow-in faster and be more stable than one with an infiltration rate of 20 inches per hour and 2 percent silt and clay. So it is an easy recommendation to make—build a USGA-type field at the maximum limits of silt and clay content.

It is extremely difficult to locate a sand that naturally contains sufficient silt and clay that targets good stability and meets the minimum performance criteria relating to soil water, i.e. aeration porosity of 15 percent, capillary porosity of 25 percent and K-sat 6 inches per hour. Most sand suppliers have clean sands containing less than 2 percent silt and clay. These sands can be amended with peat to work well for golf, but not so well for football fields. Soil must be mixed with the sand to raise the silt/clay level to between 6 to 15 percent on a weight basis. A good supply of clean and shredded soil is necessary. Reputable blenders, sand suppliers and soil testing companies are good

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resources for locating such a soil. Some blenders have a three-hopper blender that can mix sand, soil and peat in one process. Without this, the material swill have to be mixed twice, or it will be necessary to batch mix the sand and soil on the ground with end loaders and then run it through a blender to add the peat and thoroughly mix all three components. Extra blending means additional cost. Blending usually costs around $3 per ton of mix.

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Field stability

Field stability is critical, especially for football. The dynamic relationship that occurs between a player's foot and the field is very complicated. There are an endless number of player variables including shoe/sole type, player skill level and weight and type of foot action. Field variables include things such as type of surface, grass species, soil type, moisture content and surface mat. Though work is in progress, there are currently no standards for stability in natural grass fields.

When sand is tested for athletic fields, the coefficient of uniformity (Cu) is typically reported. Cu is a dimensionless number that indicates the gradation of a sand. It has been suggested that optimum Cu values for athletic fields should be between 2.5 and 3.5. Lower Cu values indicate a narrow gradation—all the sand particles in the same approximate size range. Sands with low Cu values will not pack tightly, resist compaction and are less stable. Sands with higher Cu values are widely graded—indicating that many different sand sizes are present. Widely graded sands pack tighter and therefore are theoretically more stable. But a sand rootzone with a high Cu value will not automatically provide a stable surface.

In my opinion, the stability of a sand-based field is determined more by the type of sod and initial rooting and less by the Cu of the sand rootzone. In any case, maximizing the amount of silt and clay in the mix will increase compaction and Cu and promote better rooting. This all translates into a better chance of making a stable surface during the initial year of establishment.

Sod should be carefully selected to promote stability in the first year and to avoid soggy surface conditions. Some specifications call for sod that is grown on sand that meets the same USGA specifications as the rootzone mix. This

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works well for baseball and soccer, but may be too unstable for football. For football I prefer a sod with some silt and clay, approximately 75 percent sand and 25 percent silt and clay. The sod usually contains mostly medium, fine and very fine sand. After sodding and before play the field should be aerified, with hollow cores removed, and topdressed with rootzone sand. Core and topdress as much as possible to remove part of the sod/soil layer and to weigh down the sod. Fields that have received two aerifications and a 3/8-inch of topdressing will be more stable by the beginning of the football season. Avoid causing too much stress from coring and topdressing on cool season sod that is laid in late spring or summer. With bermudagrass fields summer topdressing is no problem. The extra heat from the exposed topdressing will help the field knit together faster.

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Money-saving modifications

Recent modifications to the USGA concept have been designed specifically to lower cost and improve performance when building athletic fields. Reducing the rootzone depth from 12 to 10 inches can save about 17 percent of the rootzone material cost without effecting the performance of the field. In fact, you are likely to regain nearly 2 inches of depth by routine topdressing over the next five years. Changing from the USGA maximum specification of 8 percent silt/clay mixture (examples A and B) to 9 to 15 percent silt/clay (example C) has had good success on athletic fields. Another cost saving factor is the elimination of the 4-inch gravel blanket component of the USGA system.

Budget constraints may require reducing the USGA recommendation depths in both the rootzone and pea gravel layers; however, the finished field must meet performance criteria in such areas as water percolation rate, porosity and water holding capacity. Changing the particle size or depth of sand and gravel will require thorough testing to insure that field performance criteria are not compromised.

Another cost saving approach to building fields that provides adequate drainage for their intended use is the "shallow sand pad field." The depth of the sand pad can range from 6 to 12 inches with drains placed on 6- to 15-foot centers depending on the rootzone mixture. The shallower rootzone requires closer drain spacing and coarser sand.

This type of field has been used successfully in Europe and New Zealand where winter sports are often played under wet conditions. Example D represents a 6 inch sand pad field with drains placed on 8-foot centers. This represents one of the best values in rapid removal of surface water at a price that many facilities can afford.

If the above options still are beyond the budget, can you till sand into the field to reduce surface water and field hardness? In on-site mixing, it is difficult to make an accurate mixture by spreading sand and tilling it into a calculated volume of topsoil. Also, large amounts of sand are needed to reach any degree of improvement. As a target, add enough sand so that the final mixture will contain at least 70 percent sand on a weight basis. If your existing soil contains only a small amount of sand (and most problem soils contain less than 30 percent sand), you will need to add a lot of sand to only a small amount of your existing soil. Rootzone E provides an example of the final mix that is necessary to notice an improvement in the field.

The sand used to amend the soil should contain most of the particles in the medium to coarse range. On a weight basis the sand should contain a minimum of 60 percent particles 0.25 to 1 mm, less than 3 percent greater than 2 mm and less than 3 percent smaller than 0.1 mm. Starting with a soil that contains 30 percent sand, 4.4 inches of sand would be needed to mix with 1.3 inches of existing soil to achieve a modified rootzone depth of 6 inches. This process would cost a minimum of $35,000 to incorporate the sand, level the field and apply seed.

The problem comes in the expectation of field performance. This is not a rapid draining sand-based system. It is unrealistic to think that tillage equipment is precise enough to mix 1.3 inches of existing soil with 4.4 inches of sand. Consequently, it is difficult to specify performance criteria. A percolation rate of 1 inch per hour would be considered very successful for this type of field modification. Because the silt and clay content is still 20 percent on a weight basis it is very likely that compaction and muddy conditions are still possible. However, this modification should improve the ability to absorb small rain showers and produce better growing conditions.

The question is, do you want to spend that $35,000 and still play in the mud during excessive rain, or would that money be better spend on an aggressive Vertidrain and topdressing program, or possibly modifying a shallow sand pad to fit your budget?

Other systems, such as the sand grid system, have gained popularity in the United States. This system does not have a sand pad and does not mix sand into the existing soil. Instead, the drainage grid consists of a cross matrix of 3-inch wide trenches. Drains are spaced from 5 to 10 feet apart and are filled to the surface with sand. The system has been used in Europe for over 20 years and for $80,000 to $120,000 it is an effective way to quickly remove water that normally ponds on the surface of heavy native soil fields.

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