FEATURE ARTICLE

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How Do Your Bunkers Liner Up?

Bunker liners have been used increasingly in new construction and remediation projects for approximately five years, although the background geotechnical engineering and geosynthetics knowledge has been in use for decades in more traditional civil engineering applications (e.g., road construction, shoreline protection, etc.). The benefits to the golf course in using bunker liners are: dramatically reduced bunker sand washouts due to rain and reductions in labor expenses for associated sand repairs. Bunker liners have been shown to prevent contamination of bunker sands and improve the overall aesthetics, playability, and consistency of the bunkers on the course.

Technical Performance

In the context of this article, a 'bunker liner' is actually a relatively thick and highly permeable geotextile-like product specifically intended to drain and stabilize bunker sand. Bunker liners typically vary in thickness from ½" to ¾" or more. Thicker, higher drainage capacity products are often selected for steeper flashings or for more critical bunkers while thinner, lower drainage capacity products may be used for flatter areas or where drainage demands are less critical. Most products are made of polyester or other durable synthetic fibers, bonded together by synthetic, non-water-soluble resins. These products are substantially different from the more traditional, much thinner, needlepunched, non-woven geotextile products used in civil engineering applications. Traditional geotextiles have been used in the past in bunker applications but with mixed to poor results. Today's commercially available bunker liner products (e.g., SandMat, Sandtrapper, and Sand daM) all vary somewhat in their appearance and width but all have demonstrated an ability to function successfully for their intended purpose (i.e., sand stabilization, subgrade separation, filtration and drainage).

In the intended application, the bunker liner is designed to relieve the bunker sand of potential excess pore water pressure build up and to transfer the water as quickly as possible to the bunker underdrain system. It is not the role of a bunker liner to replace an adequate underdrain system. Without an adequate underdrain, the water will still stay in the bunker! By rapidly removing water from the sand, sand saturation and build up of pore water pressure is prevented and the sand retains its natural stability (governed by its internal angle of friction, or repose, which is dictated by such factors as grain size distribution and angularity, etc.).

The key to long-term performance of a bunker liner performing in a drainage capacity is ensuring that, long-term, the permeability of the geosynthetic bunker liner always exceeds that of the overlying bunker sand. For example; although reasonably well suited for many drainage applications, traditional needlepunched geotextiles do not possess sufficient permeability to perform long-term in this application considering the various factors that can reduce performance (i.e., such factors as soil clogging, chemical clogging, biological clogging, soil intrusion and creep).

Product Selection

A review of the literature on the subject of recommended bunker sand permeability, 'k,' (properly called *hydraulic conductivity*, but also called 'infiltration rate') suggests consideration of bunker sands with a minimum value of "20 inches per hour"

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(0.014 cm/sec) ? although initial values may be as high as "50 inches per hour" (0.035 cm/sec) (Moore, J.F. "How to select the best sand for your bunkers," *USGA Green Section Record*, January, 1998). Recognizing that geosynthetics are susceptible to long-term performance reductions due to the factors indicated above (which when summed can produce a total reduction factor in the realm of two orders of magnitude vs. initial specification values), it is important to select a product that offers sufficient drainage capacity, that when performance is reduced by these factors, still provides a suitable factor of safety compared to the permeability of the sand. Bunker liners often require initial permeabilities in the range of 5,000 inches per hour (3.5 cm/sec) to 8,000 inches per hour (6.0 cm/sec) in order to ensure adequate drainage capacity long term.

The decision on which bunker liner to use is usually a complex one often involving the clubs greens committee, possibly an architect, possibly a contractor, and, hopefully always, the input of the golf course superintendent. Larger remediations usually involve architects and many architectural firms are now quite familiar with bunker liner usage and installation. Factors that come into play are materials cost, installation cost (usually driven by roll width, with wider roll materials usually being the most effective due to reduced factors for overlap and waste, plus faster coverage), availability of a warranty, and proven performance for the intended purpose.

Installation Considerations

Installation of bunker liners is a fairly simple, yet often labor intensive, operation usually involving such high-tech equipment as steel staples, heavy duty scissors and rubber mallets. The product itself is shipped to site in plastic-wrapped or bagged rolls (roll widths vary from about 6 feet to 10 feet depending on the manufacturer). In new construction the liners are placed over the prepared subgrade after the drainage lines have been placed. The rolls are deployed, overlapped, stapled or staked to the ground and trimmed to the desired outline. Bunker sand is then added. In a bunker remediation, the existing bunker sand is removed prior to installation of the liner.

One of the first questions that should be asked is "what kind of subgrade soils exist on the golf course?" In the coastal areas of the southern United States and throughout much of the Caribbean for example the soils tend to be highly saline and fairly corrosive. Very 'fat' heavy clays can also be quite corrosive. Corrosivity of the subgrade soils can have an impact on the selection of the soil fasteners used to fix the bunker liner to the soil. Corrosion of the soil fasteners (the staples) can have an effect on the long term performance and effectiveness of the liner. The dead weight of the bunker sand is not itself enough to hold the bunker liner in place. If insufficiently fixed to the ground, foot traffic and the action of mechanical raking can result in the bunker liner tending to 'float' up into the bunker sand.

If the staples corrode badly enough there is essentially nothing holding the bunker liner in place. On steeply flashed bunker areas the soil fasteners are needed to adequately fix the liner to the subgrade and successfully transfer shearing forces caused by frictional effects of the sand with the liner into the subgrade material. Improper soil fastener selection can have severe implications for the stability of the bunker liner and the overlying bunker sand. On steep, flashings staples are usually placed on 6" to 8" spacings. On flatter floor areas, spacings on staples can be opened up to 12" or more depending on the firmness of the subgrade soils. On average, you should allow between 1.5 and 2.0 staples per square foot of bunker liner.

Absolutely avoid use of 'sod staples' for fixing the bunker liner to the subgrade. Sod staples will corrode and potentially impact the liner's performance. For most soils, use of corrosion resistant, bezinal-coated steel staples is adequate. The length of the staple is usually 6" to 8". Longer staples may be required in very sandy conditions (use of 12" 'washered pins' to hold the liner down is not unheard of). For very corrosive soils the use of plastic stakes is highly recommended. At least one bunker liner manufacturer now offers heavy duty plastic staking for corrosive environments.

Although bunker liners can contribute to improved drainage and bunker sand consistency throughout the entire bunker, very often, for economic reasons, bunker liners are placed only on the sloped faces of the bunker. In these cases the bunker liner should be terminated within the bunker by folding or running the liner into the gravel drain line at the toe of the slope. Otherwise the liner can usually be extended over top the gravel trenches.

Aesthetics and Maintenance Issues

The next major question to be asked is "how are the edges of the bunkers to be maintained?" This is usually a thorny issue since it speaks to the 'architectural appearance' of the bunkers, which may be somewhat in conflict with the desired lowest cost maintenance practices available. How the edges are to be maintained directly effects the installation of the bunker liner, specifically as to how it is to be terminated around the bunker perimeter.

If the surrounding turf is to be allowed to 'droop' over the edge of the bunkers (with maintenance usually involving a wire trimmer, 'weed whacker,' or similar treatment) then the bunker liner can often be terminated directly below the turf so that exposed edges of the liner are covered over by the 'drooping' turf. Stapling or staking can be accomplished around the perimeter by stapling or staking horizontally back into the perimeter soils (with the liner terminated vertically around the lip in this case).

In some existing course remediations, and depending on the turf type, it is common practice to trim away 12" to 18" of turf from the perimeter and run the bunker liner up over the lips and out to the trimmed distance, stapling or staking vertically down through the liner into the exposed soil (with the liner terminated horizontally around the perimeter). The trimmed turf is then placed back, directly over the liner, possibly with some top soil added first. Again, this practice depends on the turf type.

If neatly trimmed and exposed soil lips are to be the expected norm then the bunker liner needs to be terminated low enough so that edging equipment does not cut the liner or hit buried staples. Terminating the bunker liner horizontally at the base of the vertical sand shelf effectively reduces the risk of cutting the liner. However, in certain soil types, leaving the vertical sand shelf or lip area unlined can contribute to contamination of the bunker sand due to soils bleeding laterally into the sand. It is also common practice to cut a slot (e.g., with a spade) into the subgrade soils on the slopes and wedge the liner back into the soil. This can be tedious work but does help anchor the liner and prevent any loose edges from becoming further exposed or snagged.

Other Considerations

An issue that has literally surfaced with bunker liners, particularly in northern climates, is frost heaving of the staples up into the bunker sand or turf. Frost heave can only occur if there is a frost susceptible soil (e.g., silty soil), water, and freezing temperatures. Although some research is being conducted into this phenomenon, if the soils on the course are highly frost susceptible, over excavation of the bunker subgrade soils and replacement with clean granular fill is likely the best solution. Obviously the added cost of this activity would need to be weighed against the benefit of the liner on the course's future maintenance budget and desires for improved bunker sand aesthetics and playability.

The decision on which bunker liner to use is usually a complex one often involving the clubs greens committee, possibly an architect, possibly a contractor, and, hopefully always, the input of the golf course superintendent.

The largest concern cited for bunker liners is snagging of the liner by mechanical raking equipment and the need for increased hand raking. If proper staple or stake selection is made in consideration of the potential for corrosion, and if stapling or staking is done properly with the right staples and in the proper quantity, then 'floating' of the bunker liner and snagging on rakes should be easily avoidable. Regular checking of the bunker sand depth to ensure at least 4" sand cover is always recommended.

There is a growing trend towards use of recycled waters for irrigation. Typically recycled irrigation water is also quite saline. If the golf course is using or going to be using recycled water for irrigation, the impact of the resulting salinity on the bunker liner soil fasteners should also be taken into consideration. Use of plastic stakes is usually recommended in these cases. **-OC**

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