Bunker Specification & Installation Guidelines

The bunker liner product shall be CAPILLARY CONCRETE, a patented product, which is a specially formulated mixture of acceptably sized aggregate, various proprietary additives and water that must be uniformly mixed in a concrete mixer before installation. This creates a homogenously blended mixture that is poured from the mixer into heavy-duty utility vehicles, transported to the bunker and placed inside the bunker at a minimum depth of 2 inches (5 cm). The surface of the product is compacted with a roller and covered in plastic for a minimum of 24 hours to allow for adequate curing before sand is placed on top of the product. The result is a strong, homogenous and uniformly bonded product that allows water to drain through it at hundreds of inches per hour to prevent erosion and reduce contamination of bunker sand.

PRE CONSTRUCTION PLANNING

SUBGRADE PREPARATION, BUNKER SHAPING, AND DRAINAGE

Prior to installation of Capillary Concrete, the Contractor, or Owners Representative, or Superintendent shall confirm that the perimeter area around the bunker does not channel excessive water into the bunker area, the bunker subgrade is positively pitched, stable under foot, smooth, compacted, free of debris and meets the Architect’s design specifications. It must also be ensured that all bunker trenches have been excavated and constructed to specifications and drainage pipes and bedding gravel have been installed to the Architect’s drainage specifications as dictated by site conditions. After drainage installation, it must also be confirmed that the drainage system is functioning properly before installation of Capillary Concrete. It is recommended that a tracer wire be installed in all drainage trenches. The drainage pipe must be flushed with plenty of water to ensure proper function. The point of discharge must be located and water exiting the pipe must be documented. This is a very important step, as the Capillary Concrete system will not work properly if the subsurface drainage system is not functioning.

To maintain the pervious nature of the product, every effort should be made to prevent soil contamination of Capillary Concrete during installation, curing, and prior to sand installation.

Two methods to safeguard your installation from contamination:

1. Grassing around the perimeter of the bunker prior to Capillary Concrete installation: With this method, it is recommended that turf grass around the perimeter of the bunker should be secured to the soil by roots or staples before the installation of CAPILLARY CONCRETE. After Capillary Concrete installation and curing and a water test has been performed to ensure drainage function, sand can be installed in the bunker. For newly sodded bunkers, where additional irrigation is required for rooting and establishment, we recommend that a thicker layer of sand (approx. 8-10 inches high x 10 inches wide) (20-25 cm x 25 cm) be installed on inside perimeter of the bunker against new sod. This is done to allow the sand to act as a filter layer to catch any soil runoff during irrigation cycles on the newly placed sod. Once the sod is established and irrigation cycles are reduced, any contaminated sand around the perimeter should be removed. Bunker sand can be leveled and normal bunker maintenance practices can begin.

2. Capillary Concrete installation prior to sod placement. In situations where grass cannot be installed prior to the installation of Capillary Concrete, extreme care must be used to prevent soil contamination. Sand should be installed immediately after curing and the water test. As in method 1, a thicker perimeter layer of sand should be installed to reduce soil contamination prior to sod placement. After establishment, any contaminated sand around the perimeter can be removed.
THE BUNKER EDGE

The edge detail often gives the bunker shape its distinctive style. Capillary Concrete has the unique ability to be formed to fit any Architects design goals. Preserving the desired style or motif and reducing ongoing maintenance is critical to the success of any bunker restoration/renovation plan.

CapillaryConcrete
Typical Construction Detail - Exposed Soil Edge

CapillaryConcrete
Typical Construction Detail - Rolled Over Sod Edge
Some suggested edge detail methods:

1. Existing bunker and sod renovation-
The strength of Capillary Concrete allows the opportunity to protect the inside wall of the bunker better than any other product. Capillary Concrete has the ability to be shaped almost vertically at installation to get the least possible amount of soil in contact with the bunker sand. In this photo the subgrade under the existing turf has been excavated 3-4 inches (10 cm) and a layer Capillary Concrete has been placed under the sod to help protect the edge from collapse and contamination. Sand is pulled up the face to hide the Capillary Concrete edge.
2. New sod layer around the perimeter-
In this case, either the existing soil and grass, or sod is utilized as the edge of the bunker. The 2-inch (5cm) layer of Capillary Concrete meets the edge of the bunker. Rolling the sod over the face to cover the soil is an option.

Another option that has been effective is stabilizing the perimeter of the bunker edge by using thick sod pieces laid with grass facing the inside edge of the bunker. The roots and thatch help to stabilize the edge and help keep the edge from collapsing. Place the sod pieces along the inside edge (grass side in), like in this picture, before installing the Capillary Concrete layer. On steeper greenside slopes, it is recommended that a notch approximately 2” (5 cm) deep and 2” (5 cm) wide be installed around the perimeter of the bunker where the vertical lip meets the floor of the bunker to create a “footer” to support the structure. (please ask us for detailed drawings as needed or desired).
Here, a shelf edge is created with a trowel, and carefully compacted on all sides. Two to three layers of natural sod or PermaEdge artificial sod can be placed on the shelf and backfilled with acceptable material or material specified by the PermaEdge manufacturer. This provides a stable and easy to care for edge option with very little contamination potential.

**SAND TESTING**

Capillary Concrete has an open structure that allows water to freely drain through the mix at hundreds of inches per hour. Once sand is placed on top of the product, the new water drainage limit will be the Ksat (saturated hydraulic conductivity) of the sand that covers the Capillary Concrete product.

After gravitational water has freely drained from the sand, a certain amount of water will always be retained in the sand against the force of gravity. This is known as capillary water and the amount can be determined with a water release curve test by an accredited test lab. Every different bunker sand has its own unique
amount of capillary water retention based on its particle shape and size. This capillary water retention can have an effect on playability and also help you determine how much sand is required in your bunkers to achieve desired playability based on the amount of moisture retained in the sand you select.

Sand particle size, color, shape, compaction rating, drainage characteristics, are subjective and exclusive to each project based on budget and desired playability at that particular golf course. Capillary Concrete requests that a USGA approved test including a water release curve be performed on any sand considered for use in the bunker.

**CAPILLARY CONCRETE MIX DESIGN**

In North America, the mix will likely be delivered to the golf course in a ready mix truck with all additives homogenously mixed and ready for installation after a few simple steps. Before the project begins, Capillary Concrete will contract with a local ready mix supplier to formulate a **Custom Mix Design specifically for this project** using an acceptably sized aggregate with adequate void content and dry rodded unit weight that falls within the standards accepted by the USGA for drainage and greens construction. This gradation of the gravel should also be compatible with the selected bunker sand.

**Pre-Construction Checklist and Instructions**

**Equipment and Tool Requirements**

<table>
<thead>
<tr>
<th>1</th>
<th>Heavy-duty vehicle to haul mix from the ready mix truck to the bunker. Examples: Toro Workman, John Deere ProGator, Tractor and dump trailer, articulating wheel loader, front dumper, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Plywood or similar to protect turfgrass and bunker edge and for building a ramp into the bunker if desired. Timbers, logs, etc. can also been used to create ramps.</td>
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</tbody>
</table>
3 A minimum of eight pieces of 4” (100 mm) to 6” (150 mm) diameter irrigation or drainage pipe cut into 2 inch (50 mm) lengths. Use these rings to maintain the 2 inch (50 mm) required minimum depth of the Capillary Concrete during placement. Remove the rings from the wet mix as you work out of the bunker. Attach a handle or make a wire loop on each piece of pipe to avoid losing them in the mix.

A metal probe set at 2 inches (50 mm) is also acceptable.

4 Flat shovels for placement of the mix.

5 A minimum of three plastic bunker rakes—the Accuform type bunker rake with a round head is preferred. The teeth can be used to rake out footprints in the mix and spread to the mix to a 2-inch (50 mm) depth, and the rounded back side can be used to smooth the mix before rolling.

6 A minimum of two one piece metal extension handles with METAL TIPS. Telescoping handles are not necessary. Metal handles and tips are necessary to reduce flexing during rolling.

*Home Depot has an orange metal 5 ft. handle with a metal tip in the paint department. SKU#821-423.*

7 A minimum of two heavy duty 9 inch (23 cm) roller frames.

*Home Depot has a green Wooster Surelock handle that works well. SKU#150-345.*
8. A minimum of two 9 inch (23 cm) loop textured roller cartridges, if the textured roller can’t be found, use a regular paint roller with the fabric removed or cover a roller with duct tape.

*Home Depot used to call them Goop Loop Rollers. SKU#430-546.*

9. At least One 12 to 14 inch pool trowel. (30-35 cm) Some installers prefer using at larger trowel for finishing the floors as well. Do not use a bull float.

*Home Depot Part# PT144BR*

10. Rolls of 6 mil Clear plastic (20ft x 100ft per roll) (6 x 30 meter)
Use Black when temperatures are expected to be below 40 degrees F (4 °C) during installation and the night after. Purchase adequate plastic to completely cover all the Capillary Concrete bunkers completed in a day. The plastic can be reused for the entire project.

*Home Depot SKU#938-963*

11. 6 inch (15 cm) metal staples to hold the plastic down after placement. Staples should be placed every 3 feet (0.9 m) round the perimeter of the bunker. Sandbags, Bricks, logs, old tires etc. are also acceptable. The idea is to hold the plastic in place during curing.

12. Two 5 gallon (19 liter) buckets of water to keep rollers wet.
A hose and quick-coupler with a misting nozzle and working shut off valve for misting of the product during installation.

Optional: For easier placement of material.

Marshalltown 19-1/2 in. x 4 in. Aluminum Placer
Home Depot SKU #959687 Model #AP753

INSTALLATION INSTRUCTIONS

NOTE: CAPILLARY CONCRETE should not be installed when temperatures are expected to be below freezing within 2 days of installation. During hot weather, windy, or low humidity conditions, the product will set up faster and caution must be exercised to maintain acceptable moisture levels of the mixture and bunker base prior to installation. A light misting of the bunker subfloor may be required several times during the installation process.

The table below describes the installation process.

- Instruction items A through F are specifically for mixing Capillary Concrete using a tractor mounted PTO driven mixer, aggregate and our admixture bags.
- Instruction item B1 begins the installation process for Capillary Concrete when using a ready mix concrete truck.
- Instruction items 2-10 are common installation guidelines for both processes.

THE PTO MIXER/AGGREGATE/BAG OPTION INSTALLATION PROCESS BEGINS HERE.

A When using LWA (lightweight aggregate), the LWA bag or pile must be irrigated for at least 45 minutes not less than 12 hours prior to installation. Local stone does not have to be irrigated prior to mixing.
B  Before mixing, spray a light coating of approved oil on the mixer and tools and bed of the vehicles used to haul the mix. This will make cleanup easier.

C  Fill the mixer with your aggregate to the fill line located on the inside of the mixer. Most mixers are preset for 750 liters of aggregate. The aggregate should never be so wet that water drips from the bag or pile. Before adding the Capillary Concrete Admixture bags to the aggregate, every attempt should be made to eliminate the free water from the aggregate as this excess water has not been factored into the specified mix ratio.

D  BEFORE MIXING—ensure that the safety screens and all other safety devices are attached according to the manufacturers specifications.

   The proper batch ratio is six bags (150kg) of Capillary Concrete Admixture to 750 liters of aggregate. With the tractor in low idle, and the mixer arms turning slowly, place the unopened bags on top of the mixer and open the bags so the mix falls uniformly onto the aggregate. DO NOT ADD ADDITIONAL WATER AT THIS POINT. Mix for 3 minutes to allow the Capillary Concrete Admixture powder to completely coat the aggregate.
Now we can add water to the mixture. The base rule is 75 liters of water per 750 liters of aggregate and 6 bags of Capillary Concrete Admixture.

- Remember - the aggregate likely has some moisture in it (the LWA was saturated prior to use). You may not need to use all 75 liters of water and NEVER ADD ALL THE WATER AT ONCE.

- Until you are comfortable with the amount of moisture in the aggregate and can duplicate ideal batches, we recommend adding 1/3 of the water at first and letting it mix for 3 minutes before adding more water.

- Check the mix consistency as indicated in part A6. Then add the next 1/3 of the water. Multiple revolutions of the mixer are needed to thoroughly distribute the water throughout the mix and after the second 1/3 of water is added, you will want to be careful not to add too much water at one time now. The mix should have a shine to it that resembles melted chocolate. Never let it get soupy. After the last water is added to the mix, allow it to mix an additional 3 minutes before checking the mix and discharging.

- Once you know how much water is required to produce an ideal batch, you can add that amount of water at one time and mix for 4 minutes before discharging.

Before discharging into the haul vehicles, check that the consistency of the mix is correct. Turn off the mixer and take a handful of wet mix and squeeze it in your hand. Open the hand vertically as if shaking hands with someone and watch the mix on the surface of the hand. If there is wet paste and aggregate particles or LWA stay on the hand, the mix is right. The Capillary Concrete mix is more stable and does not flow like normal concrete. The mix should be “shiny” and “wet” looking, but not runny like soup, so it can be applied to steep bunker faces without concern of it falling down the face.
**THE READY MIX INSTALLATION PROCESS BEGINS HERE**

1. When the ready mix truck arrives at the job site, you will need to ensure the correct consistency of the Capillary Concrete before installation can begin.

   Before discharging any mix, ask the driver to spin the truck 15 revolutions to adequately mix the product. (It's been mixing since it left the plant, but we find this to be a good way to ensure mix uniformity)

   Now it's time to perform a HAND SQUEEZE TEST. Ask the driver to discharge a small amount of the CAPILLARY CONCRETE mixture into the utility vehicle you are using to haul the mix to the bunker. It should be shiny and look like **melted chocolate and rock**. Take a handful of the mix and squeeze it in your hand and release. The paste must be creamy and sticky enough for the aggregate particles to adhere to the vertical surface of your hand. If the paste is dry and powdery, the mix is a little too dry and you need to ask the driver to add water to the mixer truck. **NEVER ADD MORE THAN 3 GALLONS (10 Liter) OF WATER AT A TIME** (unless otherwise instructed by an onsite Capillary Concrete Representative) and ask the driver to turn the drum a minimum of 15 revolutions before checking the mix again. Continue this process until the mix has the feel of **melted chocolate**. Be careful not to add too much water. It's always better to add a little at a time.

   We cannot take the water out once it has been put in the mixer. The paste should NEVER be drippy and runny when you perform the hand squeeze test. The mix should always have the consistency of **melted chocolate**. **Continue to monitor the consistency as you install—YOU MUST perform the hand squeeze test occasionally to ensure consistency during the installation.** An additional gallon of water may be required after a few loads have been installed. If so-ask the driver to add one gallon and rotate the drum 15 times before discharging more mix.

   If the mix is extremely wet and runny when the ready mix truck arrives, ask the driver to spin the drum for 5 minutes to try to dry the mix up a bit. If that doesn't work and the discharged pile for testing has clogged up void space, you should **refuse the truck and send it back to the plant.** DO NOT install Capillary Concrete if the mixture is too wet.

2. If the subgrade is dry, it should be lightly misted prior to placement of CAPILLARY CONCRETE. Do not let the floor get muddy during installation.

3. Once the batch is properly mixed, begin in one corner of the bunker by spreading the mix to a depth of 2 inches (using depth gauge rings) (5 cm) Use plastic bunker rakes or the aluminum placer tools to drag out and level the product. **Make every effort to not walk on the product in the very bottom areas of the bunker.** We want to preserve as much open space for water flow as possible.
<table>
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<tr>
<th>Step</th>
<th>Instruction</th>
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<tbody>
<tr>
<td>4</td>
<td>Use the textured roller or trowels to finish and lightly compact the surface. The entire surface of Capillary Concrete must be lightly compacted to provide a smooth surface and bond the product together. Keep the roller damp during the rolling process. It is important to work quickly during this step. The sooner the product is smoothed and rolled the better. Any footprints can be raked out and leveled with the plastic bunker rakes and rerolled to make it smooth. Again—every attempt should be made to not walk on the floor of the bunkers.</td>
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<tr>
<td>5</td>
<td>The edge of Capillary Concrete must be no less than 2 inches (5 cm) thick. A hand trowel should be used to compact and finish the edge of the material around the bunker edge. (If desired, this is also the location of the drip-line irrigation option) Care must be given to prevent loose aggregate pieces from adhering to the exposed soil edge. Any loose pieces should be removed immediately.</td>
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<tr>
<td>6</td>
<td>Once an area or batch section is finished, it must be covered immediately with 6 mil plastic. Black plastic is preferred on cold days, clear plastic is preferred in the summer. Covering is important to reduce moisture loss and improve curing and strength of the mixture. In hot and windy conditions this is an even more critical step than on cool, cloudy and calm days, where evaporation rates are less. Place staples in the plastic every 3 feet (1m) around the perimeter of the bunker and as close to the mixture as possible to reduce air between the plastic and mix. If there are seams between plastic pieces, use something heavy to hold the seams down. New bunker sand is great for this. Remember we want to reduce the amount of air getting to the product as it cures. This step also keeps water from getting on it as it sets up.</td>
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<tr>
<td>7</td>
<td>The plastic must remain on the product for 24 hours or until bunker sand can be installed. This helps the product cure and will keep the product clean and debris free.</td>
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When the CAPILLARY CONCRETE mixture is solid to the touch (minimum of 24 hours after installation), remove the plastic and allow the product to become light gray in color. Then the base of the bunker shall be cleaned with a backpack blower to remove any loose surface pieces that may not have adhered during the rolling phase of the installation. Check the edge for loose pieces as well and remove them from the soil edge.

Now perform the water drainage test to confirm that water rapidly drains through the product. This must be done to activate the Insured Financial Guarantee. Do not “blast” high pressure water on the freshly installed Capillary Concrete - a shower spray is preferred over a steady stream. See the film, The Test of Drainage.

Bunker sand can now be installed to the desired or specified depth using a conveyor, loader or utility carts etc. Do not drive directly on the new Capillary Concrete during sand installation. It is recommended to begin sand installation on an edge and push the sand out across the bunker using a sand rake or similar machine while keeping vehicles on plywood on top of the sand layer. Once the sand has been installed, saturate the sand with water. This moisture will help the product continue to cure and help the sand firm up.

If requested by the CONTRACTOR, OWNERS REPRESENTATIVE, SUPERINTENDENT, or GOLF COURSE ARCHITECT, Capillary Concrete will provide a technical representative for installation assistance and consultation for one (1) full day on site at the start-up of a Capillary Concrete installation for the cost of basic expenses and related costs. Additional days of consultation may be requested at the same expense rate. Please provide a minimum two (2) weeks’ notice to arrange this service. For more specific questions, contact Capillary Concrete at:

Europe and rest of the world: +46 766 774 214 or kerr@capillaryconcrete.com

Americas: 321-939-4143 or hunter.smith@capillaryconcrete.com

Please visit www.capillaryconcrete.com for more information.

Link to Bunker install instructions here:
See here how easy it is – Capillary Concrete installation video from The Honors Course, USA

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