



Case Study and Observations of the integration
Of Bunkertac and Hydrotac on Golf Course bunkers
For stabilisation, hydro seeding, erosion control
And prevention of sand contamination
Using different application rates and methods

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**This report was compiled by
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Background

This report is the result and accumulation of data and observations acquired over a six (6) month period from November 2007-April 2008 which documented different processes, methods and application rates which were tried and tested in order to arrive at the best possible streamlined process for the hydro seeding and stabilisation of the bunkers.

Location

The various tests were conducted on the Nicklaus Design Serengeti Golf Estate located in Johannesburg South Africa.

Involved Parties

The tests took place with the permission of Nicklaus Design. Golf Data, as the course construction company on site worked together with Soil & Dust Solutions on various product applications and with developing the final method.

Tests

A number of specific tests were conducted on the Serengeti Golf Course development in Johannesburg, South Africa for the application of Bunkertac for:

- Bunker stabilisation
- Erosion control
- Stabilisation of vertical faces and various edge designs

A very extensive and detailed Case Study Report is available upon request, which documented the different processes, application methods and rates as well as the results and prevailing weather effects, etc. This report sets forth the conclusion in terms of the best application method.

It is important to note that Bunkertac has been proven and well documented in terms of its superior performance as a soil stabiliser.

The applications which are being outlined and tested in this report are specialized in terms of stabilisation, as it is not only focusing on stabilising the internal bunker lining, but also:

- + Stabilising specially designed “rough edges” of the bunkers which will maintain their design and shape against normal playing conditions, weather, maintenance, etc.**
- + Stabilising an internal sand layer against (and covering) the soil, which remains permanently in order to create the important aesthetics feature of the bunker being completely filled with sand up to the top edge. The challenge being the vertical angles at which the sand needs to be “permanently in place”which defies gravity.**
- + With reference to Serengeti specifically, the in-situ soil is clay, the most difficult soil type to work.**

These specific objectives are outside the typical applications and uses of Bunkertac, which is why a number of different trial sections were conducted in order to develop the best method to obtain results for the specific requirements of golf courses.

As all golf course bunkers are different in terms of style; edges; slopes; in-situ soil; and are affected by different weather and watering patterns, the information contained herein is a general guideline as to the product application rates and methods to be used. The different mixes and rates used will demonstrate the different results and can then be adapted to meet the specific objectives and soil on other courses. In terms of a general application specification we have developed one for bunker stabilisation and hydro seeding which can be found at the end of the report.

Soil & Dust Solutions recommended application rates and methods of application with the objective of yielding the most effective mix designs while simultaneously streamlining the application process, the results of which are documented in this Report.

Objectives of the Trials, which were conducted from November 2007-April 2008

The properties of Bunkertac lend it to being effective for a wide variety of applications. The objective of conducting numerous tests was to develop a successful, standardized (and proven) process for hydro seeding and bunker stabilisation.

We tested different methodologies in order to develop a set standardized method of application procedures, the specific performance objectives of the various tests and application methods conducted included:

1. The introduction and discussion of the properties and application methods and equipment that would be used for bunker preparation and treatment using Bunkertac for stabilisation of the base and edges of bunkers.
2. Demonstrate that the performance level of Bunkertac as a soil stabiliser will meet the requirements of a flexible bound surface with a high load bearing and shear strength capacity while allowing for drainage; prevent distortion and disfiguration of the bunker's shape; prevent contamination of the sand contained in the bunker and most importantly reduce initial application, repair and maintenance costs.
3. Utilizing the performance characteristics and advantages of Hydrotac as an additional component in the hydro seeding process, as a tackifier, to assist the seed and mulch to stick to the bunker surrounds, the steep bunker edges and on the Nicklaus Design "rough edge" bunker design allowing germination of grass on the bunker edges and particularly on the top of the vertical "rough edge". This is important as weather conditions and watering have a tendency to wash away the hydro seeded areas causing the contractor to have to completely re-apply the hydro seed again at a significant cost.
4. Refine the bunker preparation process and streamline the Bunkertac application methodology and application rates to be easily transferable skills; cost effective; simple to maintain and efficient to apply on a large scale basis for golf courses currently under construction and those undergoing rehabilitation.
5. Test various types of application equipment and ascertain which equipment is the most effective; economical; locally available and easy to clean and maintain.

The information contained herein is limited to the bunkers treated at Hole 10 and a waste bunker. Case study data and results from the entire testing period, which include hydro seeding and the various application methods tried and tested are available upon request.

Bunkers (stabilisation)



Sand bunkers on golf courses are, in general, pits designed to have specific peripheral configurations and contour, a specific depth and sides at a predetermined angle. Bunkers typically have 100-150mm (4-6 inches) of sand on the bottom of the pit which then tapers off to 30-40 mm (2 inches) on the sides and are surrounded by grass/sod which extends very slightly over the edges.

Generally the drainage is created in trenches lined with gravel and perforated pipe in the sub-grade layer underneath bunker base and the sand.

Bunkertac is unique in its ability to form strong yet flexible matrix of three-dimensional bonds between soil and aggregate particles. Bunkertac will allow for a stronger in situ base layer, while eliminating contamination, overlaid by the softer sand on top of this which allows for the preferred playing environment, which is an important factor to be considered at all times.

Normal usage, weather conditions and watering tend to cause the sand to retreat from the sidewalls of the bunkers and mixing with the in situ soil contaminating and discoloring the bunker sand. This is particularly common in instances where the bunker sidewalls are steep.

In addition, erosion may in some instances disfigure the specific contours or break the edges of the bunkers and will decrease the angles of the sidewalls.

This change in angle will affect the difficulty factor of the bunker. Exposure of the top angle of the bunker by maintenance workers trimming grass, etc., also allows for erosion to take place. The contamination of the sand in a bunker causes a number of problems including aesthetics, exposure for the effects of erosion, and negatively affecting the consistency of play.

The type of contamination is also important if rocks and sizable gravel are introduced, this allows for possible injury to golfers and or golf equipment and adverse playing conditions. In addition, silt and clay contaminates will not only discolor the sand but could also cause the drainage system to become clogged or blocked, requiring increased maintenance costs.

Other attempts have been made to prevent erosion, which include the use of clay, cement, bitumen and geotextiles, all of which have critical shortcomings in terms of effectiveness in performance and cost.

Bunkertac when used for stabilisation of the bunker inside and edges as well as being sprayed with a hydro seeding application on the outside perimeter of the bunker will effectively prevent erosion, runoff; the effects of contamination; and prevent any disfigurement of the bunker design.

In order to demonstrate the spectrum of performance levels of Bunkertac, increased load bearing capacity; retention of sand and shape; prevention of erosion when using Bunkertac for bunker stabilisation, and how this relates to the method of application, different methods were used to apply Bunkertac during the case studies, which included: -

1. Bunkertac being sprayed on to an un-compacted surface
2. Bunkertac being sprayed on to a compacted surface
3. Bunkertac being sprayed on a compacted and spiked surface
4. Bunkertac being sprayed on an un-compacted spiked surface
5. Varying times between compacting and spraying of Bunkertac
6. Dusting of bunkers with sand before and after initial application

The following sets forth the stabilisation and sand flashing process, which was deemed most effective.

Application for stabilisation and Sand flashing of Hole 10 Bunkers

April 21st – 25th 2008

Bunkers (A-H) and the waste bunker on Hole 10 were to serve as the premise for the official handover of the Bunkertac application process for bunkers from Soil & Dust Solutions to Andrew Mills and his team from Golf Data.

With the experiences learned from the previous trial bunkers combined with the close working relationship between Soil & Dust Solutions and Golf Data, the handover of the application process was very successful.

Using the Bunkertac application method deemed the most successful from the previous trials, the results obtained on bunkers A-H on Hole 10 have yielded the best results to date.

Preparation of the bunkers included the following: -

- The placement of the drainage systems
- Compaction of the soil bases
- Removal of all loose aggregate using rakes, shovels and brooms
- Application of herbicide for weed control
- Testing of all equipment including new spray nozzles
- Slight moistening of the soil to bring it to the desired moisture level
- Placement of a very thin layer of sand around the bunker faces

The equipment used for the Bunkertac application of these bunkers included: -

- Trailer with 1 ton capacity
- Reducers
- Connectors
- Adaptors
- Ball valves
- Rakes
- Shovels
- A 1,000 litre container
- A 5.5 horse power pump
- 25 meter 1 inch hose
- 5 meter 1 inch return hose
- 50 mm pipe
- Cam locks
- Quick releases
- Brooms
- Straps to hold the container in place
- Hand held spray nozzle
- A roller used for compaction

It is recommended to have a toolbox containing all of the tools necessary to completely strip the pump and spray nozzles on hand in case of a malfunction during application.

Product Dilution & Application Rates used:

Application rate:	.70 litres per sq meter
Bunkertac	100 litres
Water	800 litres
Area treated	143 square meters

The Bunkertac dilution used for this application included 100 litres of Bunkertac and 800 litres of water in a 1,000 litre container placed on a trailer for ease of movement between the bunkers in order to complete as many bunkers as possible in the least amount of time.

Using an application rate of .70 litres per square meter (.70l/m²) an area of approximately 143 square meters was covered with this dilution. The Bunkertac was applied evenly throughout each bunker using four coats. After a coat of Bunkertac was applied to a bunker the trailer was moved to the next bunker in order to keep the application process flowing with the least amount of down time in between coats.

A new hand held spray nozzle was used for the Bunkertac application of bunkers A-H and the waste bunker on Hole 10 which allowed for a more controllable spray rate with limited run-off even on the steepest of faces.

For these bunkers the decision was made that it is unnecessary to treat the entire bunker base and therefore an area between 1 and 2 meters wide around the perimeter of the bunker edge was treated.

Addition of Sand

Immediately following the application of the 4th coat of Bunkertac a thin layer of sand was placed in each bunker over the treated area and swept into the bunker faces using brooms.

On Bunker C a small experiment was tried: -

Twenty-four hours after the completion of the bunker the layer of sand was swept away from the bunker edges and another coat (5th) of Bunkertac was applied and then the layer of sand replaced and once again swept against the bunker faces.

This *experiment proved to be effective on the steepest faces* but not a necessary step in the application process as the application of an additional coat of Bunkertac to each bunker would be costly and time consuming.



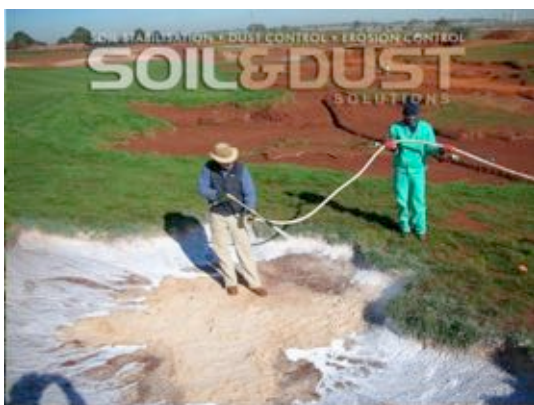
5.5 HP pump with T-fitting and quick releases



Bunker A before Bunkertac application



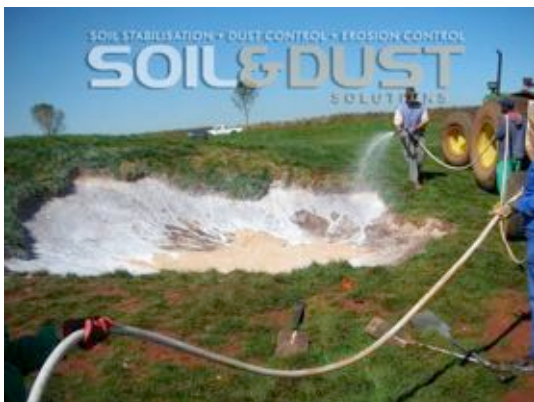
Bunker A during Bunkertac application



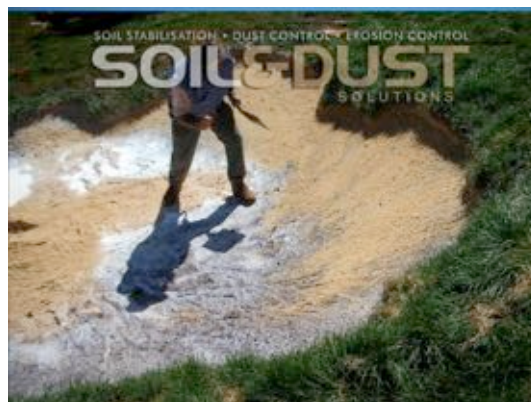
Bunker A during Bunkertac application



Bunker A after 1st coat of Bunkertac



Bunker A application of final Bunkertac coat



Bunker A sand placement after final coat



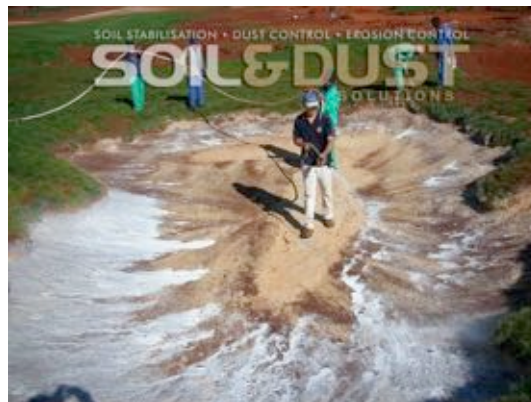
Bunker A 24 hours after Bunkertac application



Bunker A 36 hours after Bunkertac application



Bunker B before Bunkertac application



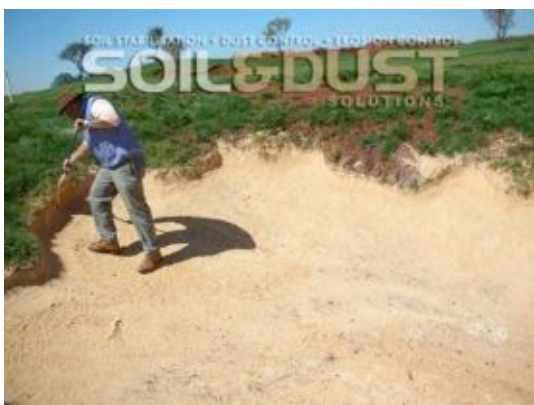
Bunker B during Bunkertac application



Bunker B sand placement after final coat



Bunker B sweeping of sand against face



Bunker B sweeping of sand against face



Bunker B 6 hours after Bunkertac application



Bunker B 24 hours after Bunkertac application



Bunker B 36 hours after Bunkertac application



Bunker B 48 hours after Bunkertac application



Bunker B receiving the approval of Mr. Jack Nicklaus during inspection conducted on April 25th 2008



Bunker C before Bunkertac application



Bunker C during Bunkertac application



Bunker C during Bunkertac application



Bunker C after a coat of Bunkertac



Bunker C 6 hours after Bunkertac application



Bunker C 6 hours after Bunkertac application



Bunker C 24 hours after Bunkertac application



Bunker C experimental 5th coat application



Bunker D before Bunkertac application



Bunker D during Bunkertac application



Bunker D during Bunkertac application



Bunker D sweeping of sand against faces



Bunker D immediately after application



Bunker D sand placement after application



Bunker D 24 hours after Bunkertac application



Bunker D 24 hours after Bunkertac application



Bunker E during Bunkertac application



Bunker E during Bunkertac application



Bunker E after final coat of Bunkertac



Bunker E 24 hours after Bunkertac application



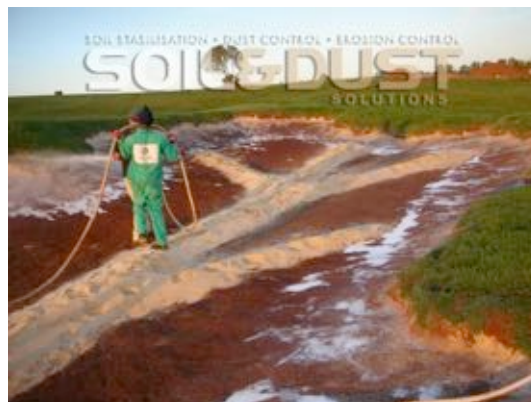
Bunker E 24 hours after Bunkertac application



Bunker E 36 hours after Bunkertac application



Bunker F before Bunkertac application



Bunker F during Bunkertac application



Bunker F during Bunkertac application



Bunker F 24 hours after Bunkertac application



Bunker F 36 hours after Bunkertac application



Bunker F 60 hours after Bunkertac application



Bunker G 24 hours after Bunkertac application



Bunker G 24 hours after Bunkertac application



Bunker G 36 hours after Bunkertac application



Bunker G 36 hours after Bunkertac application



Bunker H 24 hours after Bunkertac application



Bunker H 24 hours after Bunkertac application

Waste Bunker Bunkertac application

In preparation for the April 25th visit of Jack Nicklaus a decision was made to have the Bunkertac application process underway in the waste bunker. Andrew Mills of Golf Data thought it was best to present a bunker in varying stages of the application process for viewing to allow for a better understanding of the overall methodology. The pictures below show the waste bunker in varying stages, which include:

- Areas treated with a full four coats of Bunkertac with sand placement immediately following. (***The preferred method of application***)
- Areas treated with only two coats of Bunkertac awaiting further treatment.
- Areas treated with only an initial coat of Bunkertac with no sand in place.
- Untreated areas that have been fully prepared for application.
- Untreated areas in the middle of preparation for application.
- Untreated areas, which have been compacted only.
- Untreated areas that have not begun the preparation process.



Waste Bunker during Bunkertac application



Waste Bunker sweeping of sand against edge



Waste Bunker during Bunkertac application



Waste Bunker showing placement of sand



Waste Bunker Bunkertac area with no sand



Compaction of area of Waste Bunker



After first coat of Bunkertac to unsanded area



Preparation of Waste Bunker using brooms



Waste Bunker following first coat of Bunkertac



Waste Bunker following first coat of Bunkertac

Observations and conclusions from Hole 10 bunkers (A-H)

- Bunker base must be moist (OMC) prior to Bunkertac application.
- All equipment must be tested (off-site if necessary) prior to Bunkertac application to ensure proper functioning.
- Spray nozzles should be set to provide an even spray coat over the bunker with minimal running or draining of the Bunkertac mix.
- Proper preparation of a bunker for stabilisation includes sufficient compaction (but not over), removal of all loose soil and aggregate, hydro seeding around the outside edges, application of herbicide for weed control.
- If drains are in place, Bunkertac must not be applied to the marked drainage areas.
- When preparing the mix dilution the Bunkertac is added last, directly into the water and circulated through the return valve of the pump.
- All areas must be measured prior to application to determine proper application rates and mix designs.
- For best application, a firm round hose may be more effective than a flat hose in order to prevent kinking and allow for a smooth continuous flow rate.
- During the Bunkertac application each coat must be allowed to penetrate or “soak in”, but not dry, before applying the next coat.
- Compaction of the bunker should be done 2 to 3 days prior to application.
- All equipment used must be rinsed off thoroughly as soon as possible after application before the Bunkertac has a chance to dry or cure.
- After Bunkertac application bunkers must remain free of watering, rain and any human traffic for a minimum of 24 hours.
- The placement of a thin layer of bunker sand into the bunker immediately following the Bunkertac application before the Bunkertac has a chance to dry or cure helps to “glue” the bunker sand in place.
- Using Bunkertac for stabilisation of the bunkers provides a flexible bound surface with high load bearing and shear strength capacity while still allowing for proper drainage and germination.

- Repair and maintenance of damage to the treated areas is simple, efficient and quick (not labour intensive or time consuming)
- Spraying Bunkertac around the perimeter and high sides of the bunkers will assist in the prevention of contamination from fugitive material transported from fairways and landscaped areas nearby.
- Treatment of the entire bunker base is not necessary; an area of approximately 1 to 2 meters wide is sufficient.
- Placement of sand before Bunkertac application, although helpful is not necessary as the placement of the sand immediately following the application has proven to achieve the same effectiveness.
- The use of a tractor and trailer containing the pump and dilution container for ease of movement, after each coat of Bunkertac is applied, between the bunkers proved to be very efficient and will allow for the maximum number of bunkers to be treated over the course of a day.

For more detailed information regarding how Soil & Dust Solutions can assist you on your golf course please contact us today

We offer training on the process so that your on site crews can perform applications and maintenance.