CAPILLARY CONCRETE

CARBON FOOTPRINT ANALYSIS

2021-12-21

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Carbon footprint analysis

CLIENT

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INTRODUCTION

Capillary Concrete uses a particular concrete recipe resulting in concrete with water permeability, which can be used for several applications.

One application is golf courses, where the concrete is used together with sand in bunkers, increasing the bunker lifespan and reducing the need for maintenance and use of sand and water, compared to a conventional bunker.

Concrete is a relatively carbon-intensive material, but reduced need for sand and transportation has positive effects for the carbon footprint of the product. This analysis aims to compare the carbon footprint of the Capillary Bunker to a conventional bunker over its lifetime.

1.1 METHODOLOGY

The method used is a simplified life cycle analysis (LCA), only focusing on the carbon footprint. The methodology involves mapping greenhouse gas emissions from all phases in the lifecycle; construction, use and end-of-life, and applying emission data for all processes included. The emission data used is presented in the references chapter.

The main geographical focus on the analysis is the USA. Emission factors and assumptions about transport distances have been applied accordingly.

2 SCENARIOS

Two scenarios have been identified and modelled over 25 years, one for each solution: a golf course with capillary bunkers and a golf course with conventional golf bunkers. Each scenario is described below.

The results are presented assuming an eighteen-hole golf course in the US with approximately fifty sand bunkers, each being 100 square meters in size. This results in a total area of 5,000 square meters (54,000 square feet).

Note that the results indicate the impact from the bunkers on a full-size golf course of using the Capillary Concrete solution in all bunkers, compared to only using conventional bunkers, and do not include any other processes or materials used on a golf course, such as turf maintenance etc.

2.1 CONVENTIONAL SAND BUNKER

The conventional bunker consists of a layer of silica sand, which is applied after soil excavation. The sand is applied directly on the soil, which means that the sand and soil are mixed over time. The sand bunker is assumed to have a lifetime of approximately seven years, after which a complete renovation is made where all sand is replaced.

In addition to the complete renovations every seven years; smaller, annual sand refills are assumed. As the calculation period is 25 years, the conventional bunker requires 2,5 complete renovations during this period, where all sand is replaced.

2.2 CAPILLARY BUNKER

The Capillary Concrete solution consists of a thin layer of a specialized pervious concrete layer applied at the bottom of the bunker, which is then covered with a layer of silica sand. The concrete stops the sand from mixing with the soil which reduces the need for sand refills and increases the lifetime of the bunker.

The water permeability of the concrete means that the bunker is not flooded and keeps a stable moisture level.

3 RESULTS

Figure 1 shows the contribution to climate change from each scenario. Capillary Bunkers are associated with a lower contribution to climate change, with the bunker emissions for a full-size golf course being estimated at approximately 159 metric tons of CO2-equivalents (CO2-eq) over 25 years. The carbon footprint of conventional bunkers for a full-size golf course is estimated at approximately 377 tons of CO2-eq, meaning that the capillary concrete solution results in a carbon footprint approximately 58 % lower.

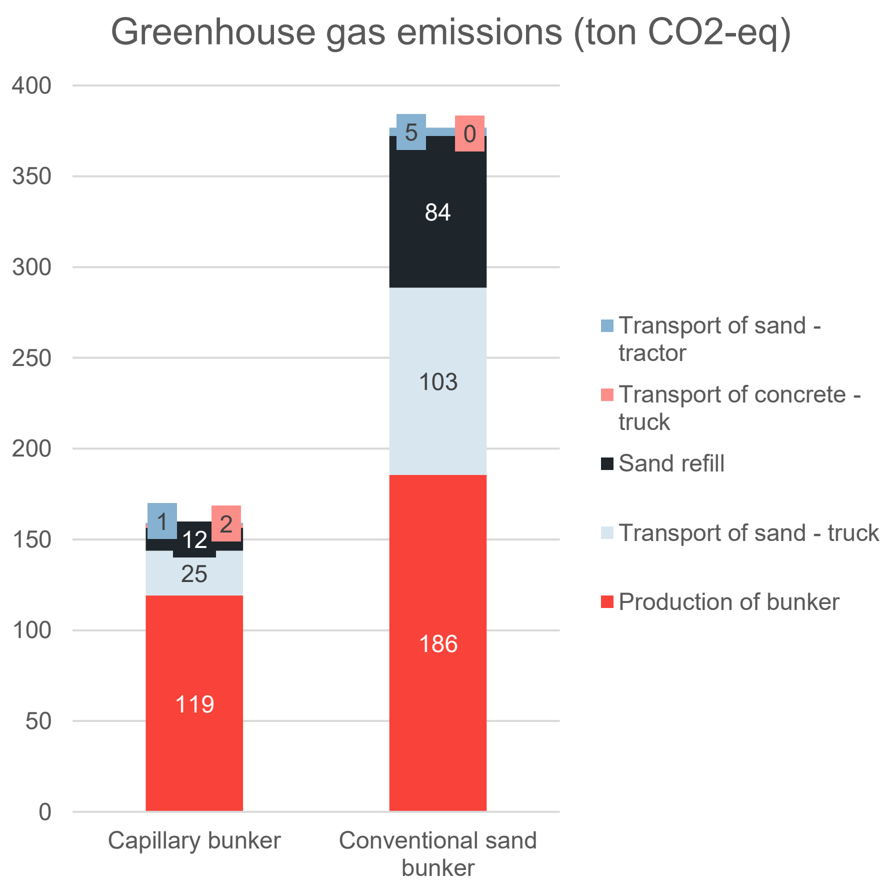

Figure 1 Greenhouse gas emissions from capillary concrete golf bunkers and conventional golf bunkers at an 18-hole golf course over 25 years

Regarding the Capillary Bunker, production of bunker in figure 1 refers to production of the concrete and excavation and processing of silica sand. The production stage has a significant impact compared to material transports and annual sand refills over 25 years.

Regarding the conventional golf bunker solution, production of bunker refers to excavation of silica sand for the initial bunker construction, as well as for the sand needed for each complete renovation every 7 years. Even though the emission factor for the sand excavation and processing is relatively low, the large sand volumes that are needed over 25 years result in significant emissions, alone exceeding all emissions for the capillary concrete solution over 25 years.

In both scenarios, sand refill refers to the annual sand refill made.

A variable with high impact on the result is the expected lifetime of the bunker in each scenario. If the lifetime of the conventional bunker was twice as long, the total emissions would be reduced by half. In that case, the Capillary Bunker would correspond to approximately 85 % of the CO2-emissions from the conventional bunker. Even though the lifetime assumption for the Capillary Bunker is assumed to be conservative – the concrete itself will last for significantly longer than 25 years – this is worth noting.

In table 1, the key parameters used in modelling the carbon footprint of conventional bunkers are tested for a full 18-hole course. It is clear that the technical lifetime is important, as longer lifetimes means reduced need for complete renovations, meaning less need for new silica sand and transportation. For comparison, a technical lifetime of approximately 17 years is required for the conventional bunkers to have a lower carbon footprint than the capillary bunker over 25 years, as is seen in the table.

Even relatively large changes to the annual sand refill requirements and the transport distances do not have the same impact to the total carbon footprint as the lifetime.

Table 1. Sensitivity testing of assumptions for conventional bunker

Parameter	**Default value**	**Changed value**	**Change in carbon footprint**	**Change in carbon footprint %**
Technical lifetime	7 years	10 years	-113 tonCO2e	-30 %
Technical lifetime	7 years	17 years	-222 tonCO2e	-59 %
Annual sand refill	7,5 %	5 %	-39 tonCO2e	-10 %
Transport distance from sand quarry to golf course	100 km	20 km	-83 tonCO2e	- 22 %

4 DATA AND ASSUMPTIONS

The calculations are based on input data received from Capillary Concrete, such as concrete recipe, assumptions about maintenance and renovation needs for both solutions, as well as expected lifetimes.

Emission factors have been retrieved from the Ecoinvent 3 database (Wernet, *et al.*, 2016), see more in the references chapter. Further assumptions are listed below.

General assumptions for both bunkers:

- The soil excavation process is not included due to assumed marginal impact.
- Silica sand is assumed to be transported 100 km by truck from the sand quarry to the golf course.
- Transportation of sand at the golf course is assumed to be done by tractor. 5 minutes of transport is estimated per cubic meter of sand.

Assumptions for the Capillary Bunker:

- The concrete is assumed to be transported 20 km by truck from the location where the concrete mix is done to the golf course.
- The concrete is applied with a thickness of 5 cm.
- The emissions data for the concrete is based on average emissions data from three concrete facilities in Florida, USA, which are considered to be representative and relevant for US conditions.
- Silica sand is used, with a density of approximately 1,600 kg per cubic meter.
- The emissions data used for the silica sand production is a global average from the Ecoinvent database, making it applicable for US conditions.
- The sand layer has a thickness of 15 cm.
- The Capillary Bunker has an expected lifetime of 25 years.
- Yearly refill of 1 % of the sand is required.

Assumptions for the conventional sand bunker:

- Silica sand is used, with an estimated density of 1 600 kg per cubic meter.
- The emissions data used for the silica sand production is a global average from the Ecoinvent database, making it applicable for US conditions.
- The sand layer has a thickness of 15 cm.
- The conventional sand bunker has an expected lifetime of 7 years, after that a complete change of sand is done. This is based on assumptions from https://asgca.org/wp-content/uploads/2016/07/asgca-life-cycle_-_final_2014_v2.pdf
- Yearly refill of 7.5 % of the sand is required.

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