Performance evaluation
DRY-TREAT S-TECH 100C™

Part I: NCHRP 244 testing, water repellency and depth of penetration on high strength concrete

Silsta Test Report number: 2-2017

Performance of S-Tech 100C™, a penetrating sealer containing 100% active n-octyltriethoxysilane (n-OTES), was evaluated on high compressive strength concrete samples prepared according to EN 480-1. The concrete cubes of 15cm length used for the test had a compressive strength of 68.7 MPa (9960 psi) after 4 weeks cure. The absorption behaviour of treated cubes was tested in sodium chloride solution according the NCRHP 244 cycle and as well in demineralised water. After immersion the drying behaviour of the blocks was monitored. Furthermore penetration depth of the sealer in the concrete was tested.

Water immersion:

Most degradation mechanisms of concrete require the presence of water to proceed. It is therefore generally accepted that keeping concrete dry can significantly extend the life span of concrete structures. The ability to absorb water can be tested by immersion of concrete specimens into water. Since the amount of water absorbed will not only depend on the test conditions used but as well on the type of concrete an untreated reference should always be tested in parallel. The water exclusion can then be calculated from the water absorption of a treated block versus an untreated reference.

Evaluation was done for different immersion times (cycle as in NCRHP 244 plus additionally 1,2 and 7 day values), experimental details can be found in the annex (table 7).

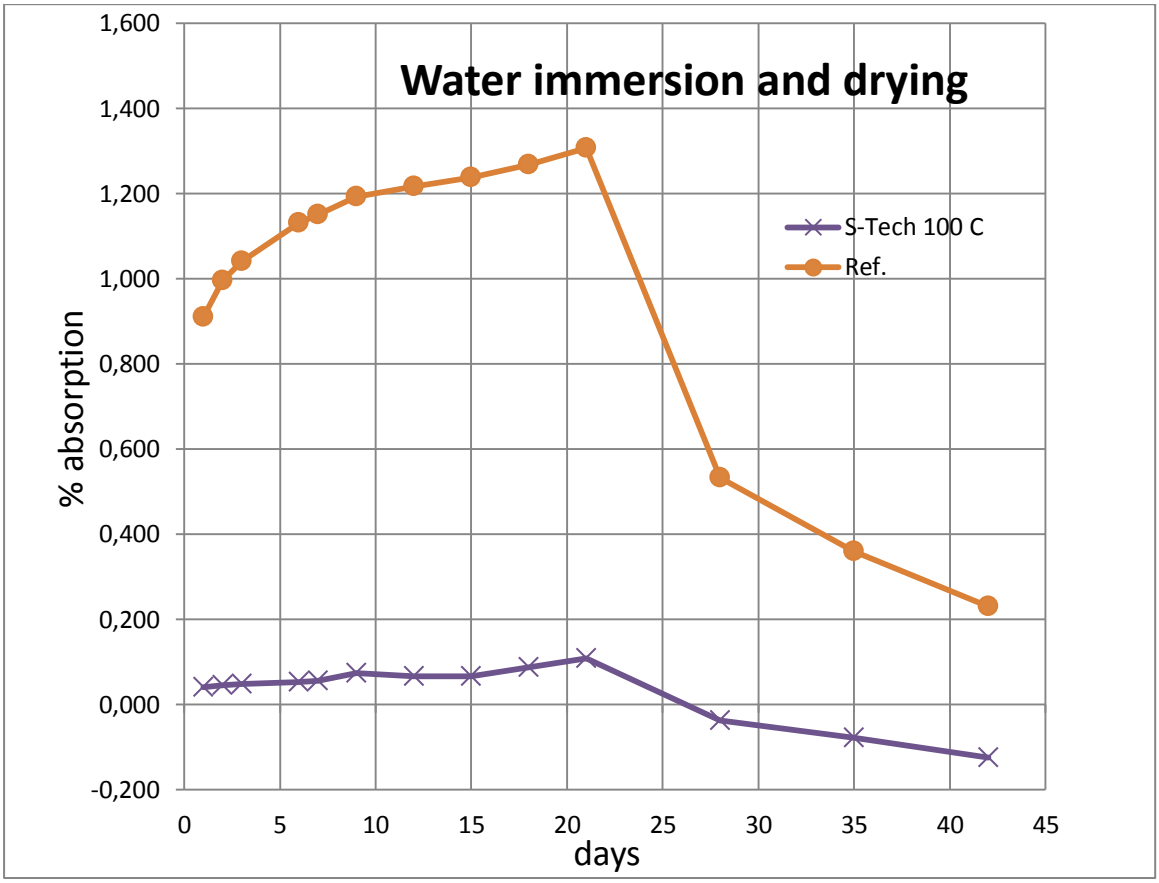


Diagram 1: Weight change of concrete immersed in demineralised water (day 1-21) and subsequent drying (day 21 to 42)

The diagram shows that the untreated concrete block readily absorbs water already within the first 24 hours of immersion. The absorption is strongly reduced for concrete treated with S-Tech 100C™ at a coverage rate of 600g/m^2.

The resulting reduction in absorption is summarized in the following table. Data for all immersion times tested are provided in the annex (table 7).

Immersion time	% Reduction S-Tech 100C™ at 600g/m^2
24 hours	95.50
48 hours	95.39
1 week	95.15
3 weeks	91.74

Table 1: Water absorption test results

The table shows that the treatment of the high compressive strength concrete with Dry-Treat S-Tech 100C™ leads to a large reduction in water absorption which is maintained during the complete 3 weeks testing period.
A reduction of more than 90% water absorption in a one week water immersion test is generally considered as a very good performing water repellent treatment. This is achieved with Dry-Treat S-Tech 100C™ at a coverage rate of 600g/m^2 even if water immersion is prolonged to 3 weeks.

Sodium Chloride immersion (NCHRP 244 series II testing):

Salt ingress, stemming from de-icing salt or exposure to sea water, is a major cause of corrosion of reinforced concrete. A chloride concentration at the rebar in the concrete above a certain threshold value will lead to oxidation and therefore expansion of the iron rebar.

A test to access the ability of a treatment to reduce the chloride ion induced corrosion is the immersion test in 15% NaCl solution as described in the NCHRP 244 report.

Evaluation was done in duplicate, experimental details can be found in the annex (values in tables 8 and 9).

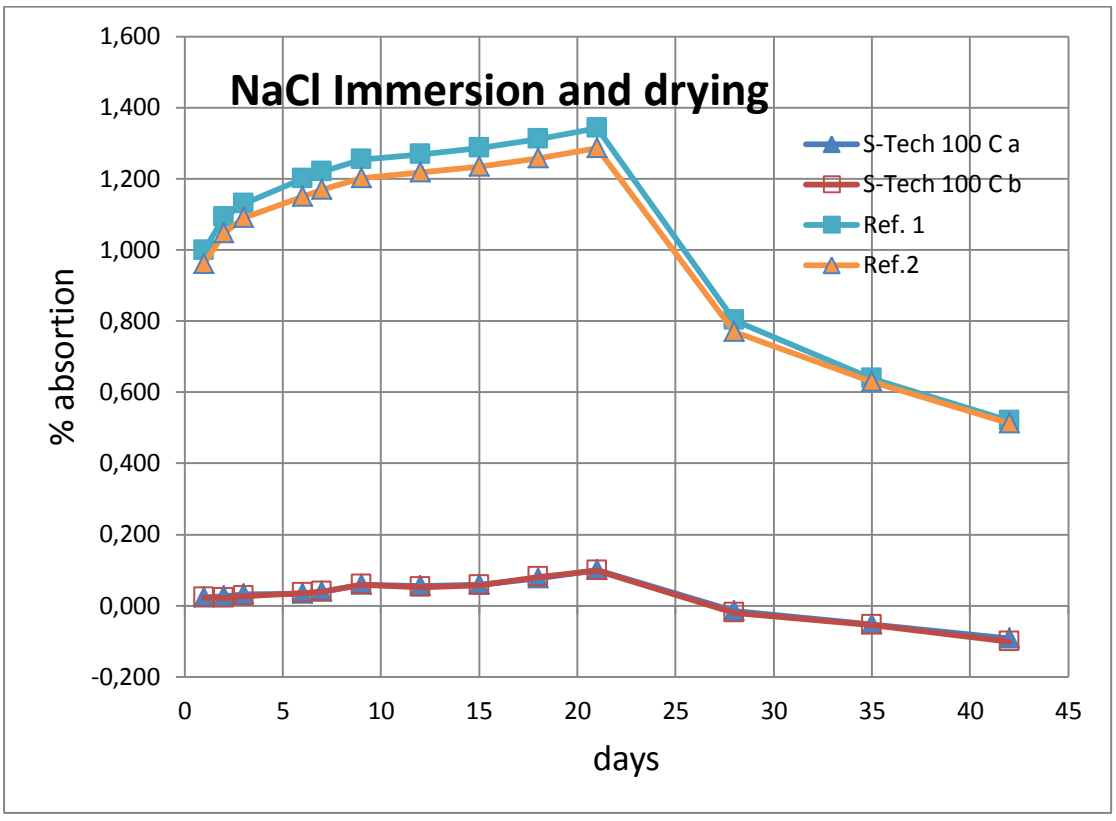


Diagram 2: Weight change of concrete immersed in a 15% NaCl solution (day 1-21) and subsequent drying (day 21 to 42)

The diagram shows that the untreated concrete blocks readily absorb sodium chloride solution already within the first 24 hours immersion. The absorption is strongly reduced for concrete treated with S-Tech 100C™ at a coverage rate of 600g/m^2. Both untreated and treated blocks show a good reproducibility among the two blocks tested.

The resulting reduction in absorption is summarized in the following table. All data are provided in the annex (table 10).

Immersion time	% Reduction S-Tech 100C™ at 600g/m^2
24 hours	97.60
48 hours	97.74
1 week	96.73
3 weeks	92.45

Table 2: Absorption test results in 15% sodium chloride solution (average for two blocks)

The table shows that the treatment of the high compressive strength concrete with Dry-Treat S-Tech 100C™ leads to a large reduction in salt water absorption which is maintained during the complete 3 weeks testing period. Since chloride ions will be transported via the liquid phase into the concrete this means that the chloride ingress will be largely reduced when concrete treated with Dry-Treat S-Tech 100C™ is exposed to de-icing salts or salt water spray close to the ocean.
The reduction requirement for the 3 week immersion is typically specified by official bodies like the DOT of certain states. The value of 92.45% reduction in absorption according to the NCHRP 244 series II testing passes e.g. the 80% value demanded by the Minnesota DOT.

Drying behaviour:

During the 3 week drying period, shown in diagram 2, the treated specimens lost more weight than they had gained during the 3 week saltwater soaking while the untreated reference lost only 61 % (average for two blocks) of the weight gained during soaking. This is the same behaviour that was found in the NCHRP 244 report for the alkyllkoxysilane tested (material number 6, 40 active% in solvent). For the drying behaviour weight loss superior to gain during soaking was classed as group 1 B. The S-Tech 100C™ would fall in the same category meaning that S-Tech 100C™ treated concrete shows good breathability which is one performance criteria for a penetrating sealer.

Depth of penetration:

Depth of penetration is the key performance criterion for durability of a penetrating sealer. The depth was determined by cutting treated concrete samples by means of a water cooled diamond disc and marking the untreated core with a water soluble dye. The distance of the stained core to the treated surface indicates the depth of penetration of the sealer. The distance was measured with a ruler to the closest mm and given as a range (due the aggregates no straight line is formed).

Treatment	Depth of penetration (mm)
S-Tech 100C™ at 600g/m^2	5-7mm

Table 3: Depth of penetration test results

For comparison the silane used in the NCHRP 244 report produced a non wettable concrete surface to a depth of 0.10 inch (~3mm).

Name, Title and Signature:

Dr. Andreas Stammer
General Manager

Mainz, the 27th of January 2017

Annex
I. Experimental Details

Concrete specimens of 15cm *15cm *15 cm size were prepared by the CRIC according to EN 480-1. In order not to interfere with any further treatment no mold release agent was used. The concrete was removed after approx. 24 h from the molds and cured for 28 day in water at 20 (+/-2) °C The composition is detailed in the following table.

Concrete composition:

Coarse aggregates	6.3-20mm	929 kg/m^3
Fine aggregates	0-4 mm	978 kg/m^3
Cement	CEM I 42.5 R HSR LA	340 kg/m^3
Water		159.7 kg/m^3
Superplasticiser	Viscocrete 1020 X (Sika)	4.08 kg/m^3
Water/Cement ratio		0.47

Table 5: Concrete composition

Air content, flow and density for the wet concrete were tested. For the cured concrete (28 days cure) the compressive strength was tested for two blocks and the average is reported.

Concrete properties:

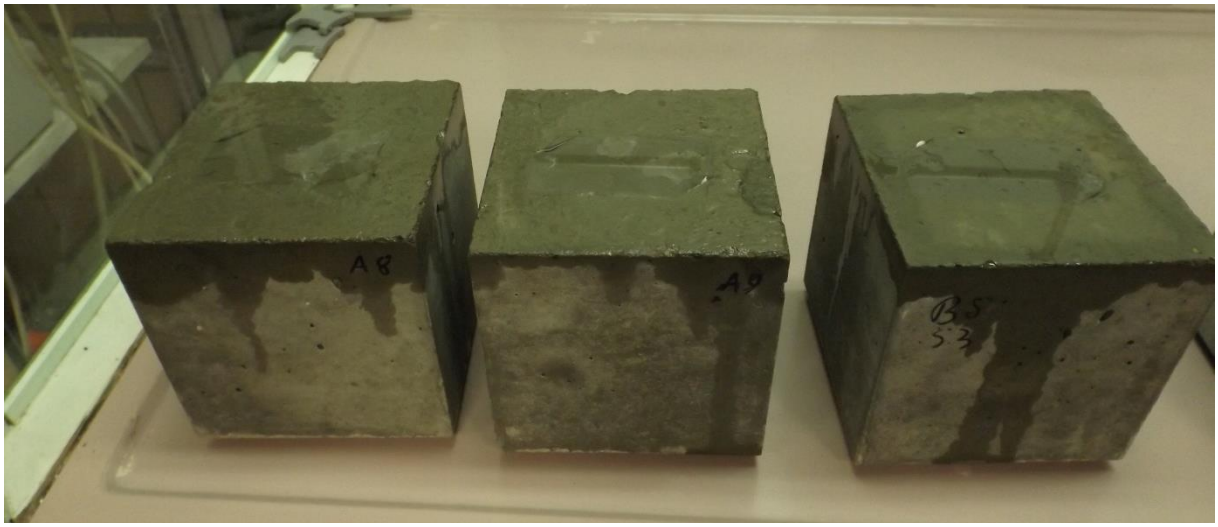
Property	Standard	Value and unit
Slump	EN 12350-2	210 mm
Wet density	EN 12350-6	2416 kg/m^3
Air content (wet)	EN 12350-7	1.6%
Compressive strength (28day cure)	EN 12390-3	68.7 MPa (9964 psi)

Table 6: Concrete properties

Conditioning:
The concrete blocks were placed on plastic rods and allowed to dry in a conditioned laboratory at 20 (+/-2) °C and 50 (+/-5) % RH prior to the treatment. The weight of the blocks was monitored on a weekly basis with a balance having an accuracy of 0.1g. During the 3 weeks drying the blocks lost approx. 0.9% of weight.

Treatment:
Dry-Treat S-Tech 100C™ was applied with a pipette to each surface of the concrete blocks and equally distributed with a brush. For one coat 6.7 to 6.8 g of S-Tech 100C™ were applied per surface (15cm *15cm), the correct amount was controlled with a balance. This corresponds to a coverage rate of 300g/m^2. This coverage rate is sufficient

to provide a treatment similar to a “flood coating” on a horizontal surface as shown in the picture below.



Picture 1: Surface of concrete blocks after application of S-Tech 100C™

A second coat of equal amount was applied 24h after the first one. The total surface coverage rate was therefore 600g/m^2.
Four blocks were treated with S-Tech 100C™ in an identical manner; two were used for salt water immersion, one for immersion in demineralised water and one for testing the penetration depth.

Cure:
The concrete blocks were placed on plastic rods and stored for 4 weeks in a conditioned laboratory at 20 (+/-2) °C and 50 (+/-5) % RH in order to allow S-Tech 100C™ to cure completely.

Water immersion:
One of the treated four blocks was used for water immersion.
After cure the weight of the block was determined with a balance with an accuracy of 1/10 of a gram. Water immersion was carried out by placing the treated block in a water bath at 20 (+/-2) °C on a plastic grid. The untreated reference block was placed in a second water bath. The surface of the blocks was covered then with 25 mm (~ 1 inch) of demineralized water. The blocks were removed from the water bath after 1,2,3,6,7,9,12,15,18 and 21days, excess water on the surface was removed with a paper towel and the weight was again determined with a balance. After weighting, the blocks were immediately placed in the water bath again. Water absorption in % was then calculated from the weight gain of the blocks. The % reduction was calculated by using the weight gain of an untreated reference as 100% uptake.

Sodium chloride immersion:
Two of the four blocks were used for immersion in sodium chloride solution.
After cure the weight of the blocks was determined with a balance with an accuracy of 1/10 of a gram. Immersion was carried out by placing the blocks on a plastic grid in a

bath filled with a sodium chloride solution of 15 wt.% (NaCl > 99.8% supplied by Carl Roth, Germany) at 20 (+/-2) °C. The untreated reference blocks were placed in a second bath. The surface of the blocks was covered then with 25 mm (~ 1 inch) of salt solution. The blocks were removed from the bath according to the cycle described in the NCHRCP 244 report (plus additional 1,2 and 7 days), excess salt solution on the surface was removed with a paper towel and the weight was again determined with a balance. After weighting the blocks were immediately placed in the bath again. Absorption in % was then calculated from the weight gain of the blocks. The % reduction was calculated by using the average weight gain of the two untreated reference blocks as 100% uptake. Two blocks were tested for each condition and the average of the two values is reported.

Drying:

After the immersion cycles concrete blocks were placed on plastic rods and stored for 3 weeks in a conditioned laboratory at 20 (+/-2) °C and 50 (+/-5) % RH, in order to allow the blocks to dry again. The weight of the blocks was monitored on a weekly basis with a balance with an accuracy of 0.1g.

Depth of penetration:

The depth of penetration was determined by cutting the treated concrete sample after the 4 weeks cure and marking the untreated core with a water soluble dye. The distance of the stained core to the treated surface indicates the depth of penetration of the S-Tech 100C™. The distance was measured with a ruler to the closest mm and is reported as a range (due the aggregates no straight line is formed).

II. Drying and immersion data

Day	Condition	Block A13 Untreated % weight change	Block A9 Treated % weight change	Block A9 Treated % reduction
1	H_2O immersion	0.909	0.041	95.50
2	H_2O immersion	0.995	0.046	95.39
3	H_2O immersion	1.041	0.048	95.35
6	H_2O immersion	1.132	0.053	95.29
7	H_2O immersion	1.150	0.056	95.15
9	H_2O immersion	1.193	0.074	93.76
12	H_2O immersion	1.216	0.067	94.49
15	H_2O immersion	1.239	0.067	94.59
18	H_2O immersion	1.268	0.087	93.15
21	H_2O immersion	1.307	0.108	91.74
28	Drying	0.533	-0.037	n.a.
35	Drying	0.360	-0.078	n.a.
42	Drying	0.231	-0.128	n.a.

Table 7: Data for concrete blocks immersed in demineralised water

Day	Condition	Block A12 Untreated % weight change	Block B12 Untreated % weight change	Average Untreated % weight change
1	NaCl immersion	0.998	0.961	0.980
2	NaCl immersion	1.092	1.047	1.070
3	NaCl immersion	1.130	1.090	1.110
6	NaCl immersion	1.201	1.149	1.175
7	NaCl immersion	1.220	1.169	1.194
9	NaCl immersion	1.253	1.201	1.227
12	NaCl immersion	1.268	1.219	1.243
15	NaCl immersion	1.286	1.233	1.260
18	NaCl immersion	1.312	1.257	1.285
21	NaCl immersion	1.342	1.286	1.314
28	Drying	0.802	0.770	0.786
35	Drying	0.638	0.629	0.633
42	Drying	0.519	0.512	0.515

Table 8: Immersion data for reference blocks immersed in sodium chloride solution

Day	Condition	Block A8 Treated % weight change	Block B8 Treated % weight change	Average Treated % weight change
1	NaCl immersion	0.022	0.024	0.023
2	NaCl immersion	0.027	0.021	0.024
3	NaCl immersion	0.031	0.026	0.029
6	NaCl immersion	0.033	0.035	0.034
7	NaCl immersion	0.038	0.040	0.039
9	NaCl immersion	0.059	0.060	0.060
12	NaCl immersion	0.054	0.052	0.053
15	NaCl immersion	0.059	0.057	0.058
18	NaCl immersion	0.077	0.081	0.079
21	NaCl immersion	0.100	0.098	0.099
28	Drying	-0.015	-0.021	-0.018
35	Drying	-0.052	-0.055	-0.053
42	Drying	-0.093	-0.102	-0.097

Table 9: Immersion data for treated blocks immersed in sodium chloride solution

Day	Condition	Block A8 Treated % reduction	Block B8 Treated % reduction	Average Treated % reduction
1	NaCl immersion	97.66	97.54	97.60
2	NaCl immersion	97.45	98.02	97.74
3	NaCl immersion	97.22	97.66	97.44
6	NaCl immersion	97.16	97.04	97.10
7	NaCl immersion	96.79	96.67	96.73
9	NaCl immersion	95.16	95.14	95.15
12	NaCl immersion	95.62	95.80	95.71
15	NaCl immersion	95.29	95.46	95.37
18	NaCl immersion	94.03	93.71	93.87
21	NaCl immersion	92.37	92.53	92.45

Table 10: Data for absorption reduction of treated blocks immersed in sodium chloride solution

Silsta GmbH
Hermann Hesse Str. 34
55127 Mainz, Deutschland
Tel.: +49 6131 2635813
E-Mail: info@silsta.com
www.silsta.com

Geschäftsführer: Dr. Andreas Stammer
Sitz der Gesellschaft: Mainz.
Registergericht: Amtsgericht Mainz
HRB 4484
VAT number: DE 290 653 256