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Report

Test Series with Ashford Formula

N° TÜV / M 01 / 1247

Object: Concrete Slab

Client: ASHFORD FORMULA
Vertrieb Deutschland
NORSA GmbH

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1 OBJECTIVE/AIM

Our client, the ASHFORD FORMULA Vertrieb Deutschland NORSA PLC is at the moment the only distribution company of Ashford Formula in the German market, mainly for the segment of industrial floors and utility floors made of concrete. We were requested by Norsa to investigate how the characteristics of concrete might be influenced by a surface treatment with Ashford Formula.

As a first step, we selected some criteria for the test series in accordance with the investigation target specified by our client. In particular, we agreed to test the concrete regarding the following characteristics:

- Curing
- Abrasion
- Impermeability / Waterproofing
- Resistance to Frost in Melt Salts
- Adherence/Coefficient of Friction
- Investigation with electron microscope

2 GENERAL FACTS AND METHOD OF INVESTIGATION

The test series started on 8/20/2001 with the pouring of a concrete slab for test purposes (1 m x 1 m x 0.20 m) outside the facility of TÜV Nord Bauqualität GmbH & Co. KG. The concrete was supplied with a concrete truck, and once filled in the mold, compacted with a special machine, to increase the concrete's density. Afterwards, half of the concrete slab was treated with Ashford Formula in accordance to the processing guidelines of the manufacturer.

Image 1: trial slab, on the left without AF, on the right with AF

During the curing period, the concrete slab was kept uncovered. After 90 days, several test cores were drilled from the treated with AF (except for the impermeability test). Moreover, the concrete samples were cast for testing.

3 Results

3.1 Quality of the test material

The concrete slab used during the investigation process was made of concrete (delivery note is attached) of the following mix design:

Cement CEM I 42,5 R	320 kg/m³,
aggregates	1.900 kg/m³, sand + 16 mm gravel,
water	160 kg/m³
water/cement ratio	0.50
additives	BV: 0.4 % by weight of cement

As we wanted to test the quality of the material (concrete) used during the test series, we investigated compressive strength, flexural strength and at last impermeability as per DIN 1048, part 5: "Test Procedures for specially prepared concrete samples." The detailed result sheets are attached for every single test. The main results are summarized below.

Table 1: Concrete Quality of the Test Slab

Criterion	Age of the test bodies	Result
Compressive strength	7 d	**28 N/mm² (4,061 lbs/in^2)**
	28 d	**38 N/mm² (5,511 lbs/in^2)**
Flexural Strength	28 d	**4.9 N/mm² (711 lbs/in^2)**
Permeability	28 d	**24 mm (0.094 in)**

3.2 Curing

The next parameter to investigate was the water retention effectiveness after having treated the concrete surface with AF, in other terms, analysing a possible reduction of water evaporation – a typical phenomenon to be observed in surfaces of fresh concrete. Therefore, we determined the water retention coefficient in accordance to the Guidelines of the Technical Delivery Conditions for Liquid Curing Agent designated to improve its resistance to atmospheric attack (Liquid Membrane - Forming Curing Compound for Concrete) (TL NBM-StB in German). Differing from the above-mentioned guidelines, 4 cm x 16 cm x 4 cm test specimens were used.

The curing compound (BNM in German) can be defined as liquid substances which are applied homogeneously on the concrete surface, forming a thin film, preventing the loss of

water from the fresh concrete. In view of this definition, AF is not a typical liquid curing compound by the above-mentioned Technical Delivery Conditions, since AF does not form a surface covering film. In fact, AF reacts with the concrete components near the surface forming a stiff compact layer.

A detailed description of the results obtained are enclosed with impermeability test certificate. The reference point of this trial, **the water retention coefficient S determined in accordance to Guidelines TL NBM –StB is 26.1 %.** The following table shows the average moisture loss for concrete treated with AF and concrete without AF. The measurements were taken at 1 day, 3 days and 7 days.

Table 2: Moisture loss

concrete age	**Moisture loss in grams**	
	with AF	without AF
1 d	**19.2**	**27.5**
3 d	**24.2**	**33.1**
7 d	**30.5**	**38.6**

Comparing the moisture loss figures obtained during the test period, the moisture loss is 30% lower in concrete treated with AF after 1 day. After 3 days, the figures are improved by 27%. At the end of the test period (7 days) there is still a 21% improvement.

3.3 Resistance to Abrasion

To determine any possible effects of AF on the abrasion resistance, 3 drilled cores were extracted from the AF - treated part only of the concrete. The preparation of the test specimens and the tests themselves were based on the instructions of DIN 52 108 “A Test with Grinding Disk by Böhme.“ The corresponding certificates are enclosed.

The test with the grinder attempt to determine the behavior of concrete exposed to rolling and/or dropping impacts. Among others, data of abrasion resistance of concrete cement - sand grout made for jointless floors were used for comparison. The tolerance in terms of minimal and maximum values as well as the relating classifications for the test series mentioned above are fixed within DIN 18 560 ”Tiled Floors in the Construction Sector,“ Part 1, table 8 and Part 7, table 6.

The following table presents the results obtained during the abrasion test. This time we only tested samples treated with Ashford Formula, tested at 4, 8, 12 and 16 days.

Table 3: Loss of thickness / loss of volume

Test periods	**Loss of thickness in mm**	**Loss of volume in cm³/ 50 cm³**
	Concrete treated with AF	
4	**0.3**	**1.74**
8	**0.7**	**3.70**
12	**1.1**	**5.66**
16	**1.5**	**7.55**

A standard concrete, classified within the quality group B 25 presents normally an abrasion coefficient of about 15 cm³/50cm², while the coefficient is up to 12 cm³/50 cm² for a concrete classified into quality group B 35.

In sum, concrete treated with AF can be assigned to the standard group 9 in accordance to DIN 18 560 Section 1, table 8, where the requirements to be fulfilled for a quality test are set.

DIN 18 560 table 6 sets the requirements to be met by a tiled floor made of cement - sand mortar with hard fine filler in order to pass the quality test.

For concrete floor group ZE 65 A (cement floors including hardening substances, class A according to DIN 1100), the limit of the volume loss is 8 cm³/ 50cm² and 7 cm³/50 cm² on average. In view of these reference values, the positive impact of AF (see table 3) becomes obvious.

3.4 Impermeability

The coring of the test specimens, their preparation and testing test series were carried out according to the technical requirements of DIN 1048 Section 1, 2 and 5. To test the impermeability of concrete treated with AF, three drilling cores of ∅150 mm were used.

Initially, three core were placed in water for three days under constant pressure of 5 bar. The characteristic investigated was penetration depth of water versus time. The level of penetration indicated in the attached test certificates corresponds to the maximum value measured during the test period. DIN 1045 requires an average penetration level of **50 mm** (maximum value permitted) for a concrete classified as impermeable and highly resistant to weak chemical attacks. For concrete with high capacity to resist against water and strong chemical impacts, this reference value is **30 mm**.

An average penetration depth 7 mm observed in the test samples gives evidence of the high impermeability of concrete treated with Ashford Formula.

3.5 Frost Resistance in Salt Solution

To investigate the capacity of concrete to resist against frost and salts, 5 core samples ∅150 mm were used from concrete treated with AF. The tests were made in accordance to the CDF-Test Instructions relevant for tests using a controlled chamber with air-conditioning system based on the circulation of cold air from outside. Certificates with the individual trial results are attached.

DIN 1045 "Concrete and reinforced concrete, mix design and manufacturing" specify several requirements regarding the mix design of concrete with high resistance to freezing. The above-mentioned DIN states that the resistance can be improved with air entrainment agents.

The following table shows the test results for concrete treated with AF versus number of freeze - thaw cycles.

Table 4: weight loss during freeze - thaw cycles.

Nº of cycles	**Weight loss in g/m²**
	Concrete treated with AF
4	**43.8**
8	**75.9**
16	**129.4**
32	**177.3**

According to the Basic Conditions, established by Prof. Setzer (Essen) the following criterion was used as the acceptable standard:

- **Average acceptable weight loss after 28 freeze - thaw cycles in salty solution is 1500 g/m²**

For the AF treated concrete the weight loss measured after 32 cycles reached average value of 177.3 g/m². According to these results, no air - entrainment agent has to be added. The treatment with AF makes it unnecessary.

The following image shows the concrete surface after the testing. The AF treated area is on the left. Obviously it presents only a minor deterioration effect as compared to the untreated area.

Figure 2: surface after the freeze - thaw tests in salty solution.

3.6 Slip prevention / Coefficient of friction.

As mentioned above, through the treatment with AF, chemical reactions take place in the top surface layer. With increasing concrete age the surface seems to become more homogeneous and smooth. In some cases slip prevention becomes an important consideration for industrial floors users. There is no standard technique for testing slip resistance, and therefore several risk groups for assessment of industrial floor were created instead. These groups include different grade of risk. Group R 9 corresponds to minor risk and group R 13 to maximal standards requirement for slip prevention.

In this research, concrete treated by AF and the control concrete (without AF) were tested to determine coefficient of friction.

The test was performed according to the standards DIN 51131. Samples in wet and dry conditions were tested. Test results presented in table 5.

Table 5: Coefficient of friction of treated and untreated concrete.

Coefficient of friction μ			
Concrete treated with AF		Concrete without AF	
dry	wet	dry	wet
0.63	**0.77**	**0.74**	**0.83**

During the comparative tests with prototypes classified as adherent, the measured value for category R 9 ($\mu = 0.52$) and for R 10 ($\mu = 0.78$) (without substances with anti-slip effects). The higher the coefficient μ, the better the adherence capacity of the surface. In practice, surfaces that reach a coefficient of 0.45 or better might be classified as secure concerning the slip risk.

As expected, the coefficients obtained are slightly less for surfaces treated with AF, pointing out that the wet surfaces show better results than the dry test specimen. Both concrete, with and without AF can be classified as adherent.

3.6 Investigation with Electron Microscope

To establish the influence a treatment with AF might have on the structure of fresh concrete, we prepared several comparative analyses with an electron microscope. For these tests, fractional concrete parts were used from both the concrete with AF and the concrete without AF.

The video print of the concrete treated with AF (images 4-6) shows a closed and dense structure, while the concrete without AF-treatment shows open pores and cavities (image 3).

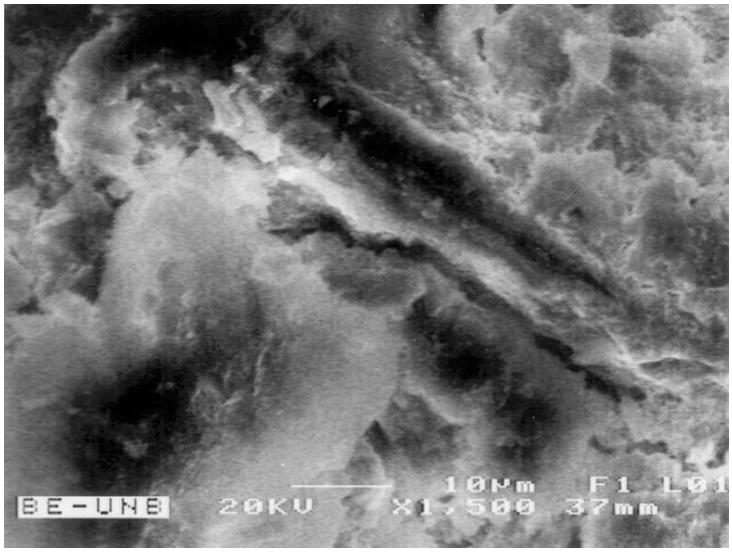

Image 3: ordinary concrete without AF, structure with open pores

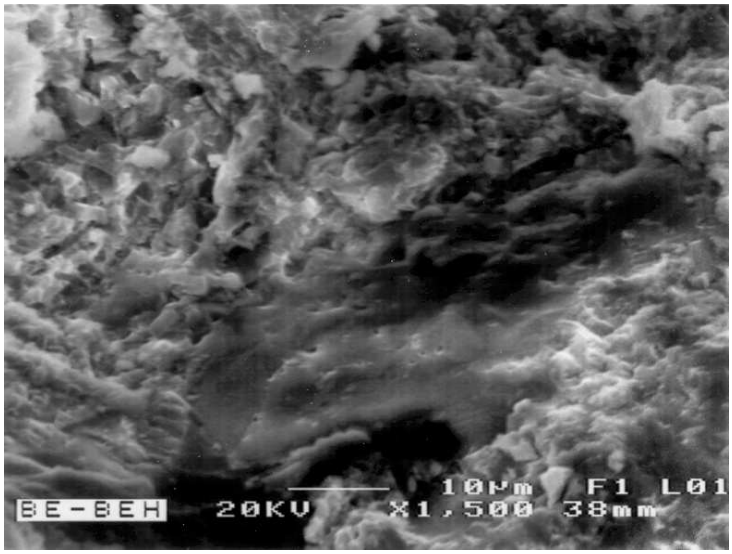

Image 4: concrete treated with AF, closed and dense structure

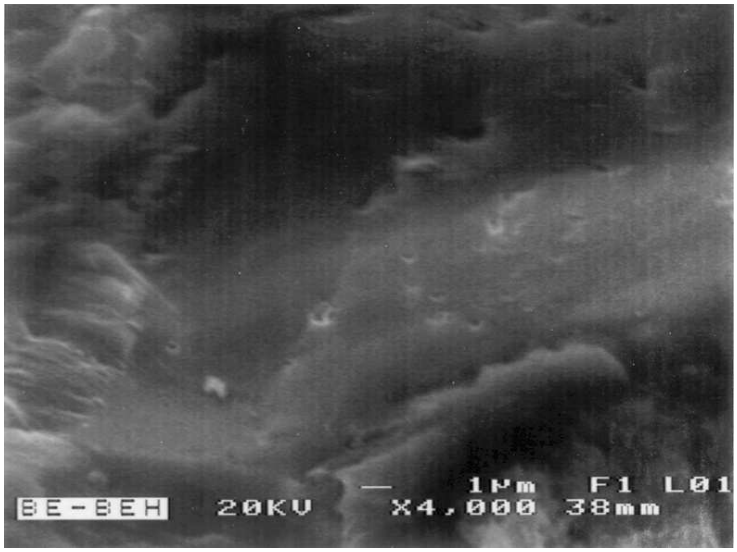

Image 5: concrete treated with AF, closed and dense structure

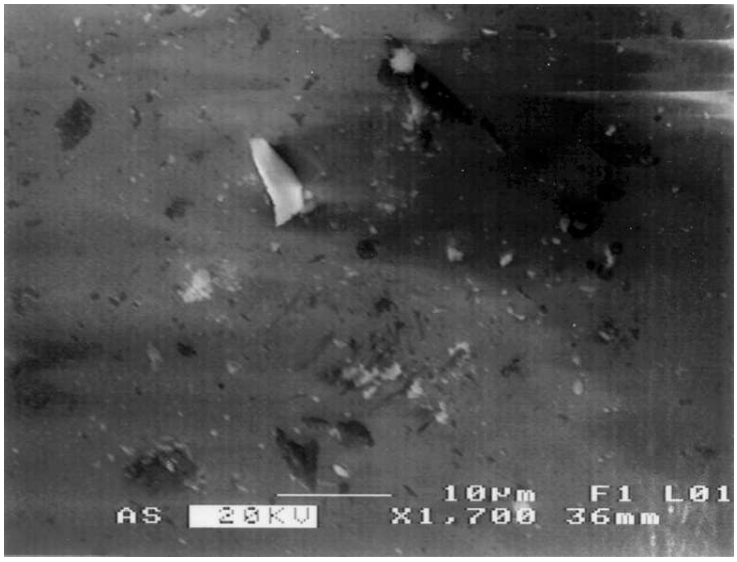

Image 6: concrete treated with AF, closed and dense structure

4 Summary

The aim of the investigation presented above consisted of issuing an opinion about a possible influence on concrete characteristics generated by the application of Ashford Formula on fresh concrete surfaces. The test series was based on a comparison between concrete treated with AF and concrete not treated with AF, laying the emphasis on the test criteria fixed at the beginning.

The following diagrams summarize in brief the results of the different tests. For more detail, please note the enclosed individual certificates.

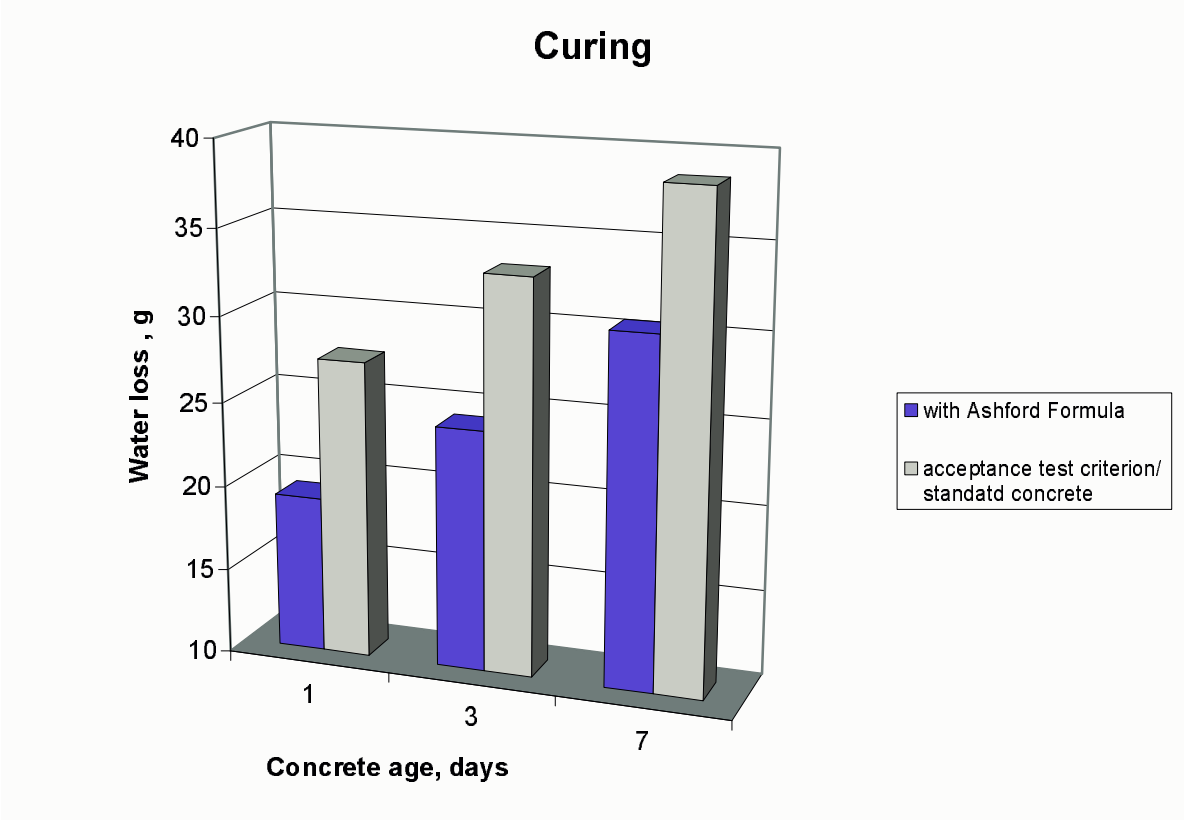

Diagram 1: Improvement of capacity for water retention - 30% (after 1 day), 27% (after 3 days) and 21% (after 7 days)

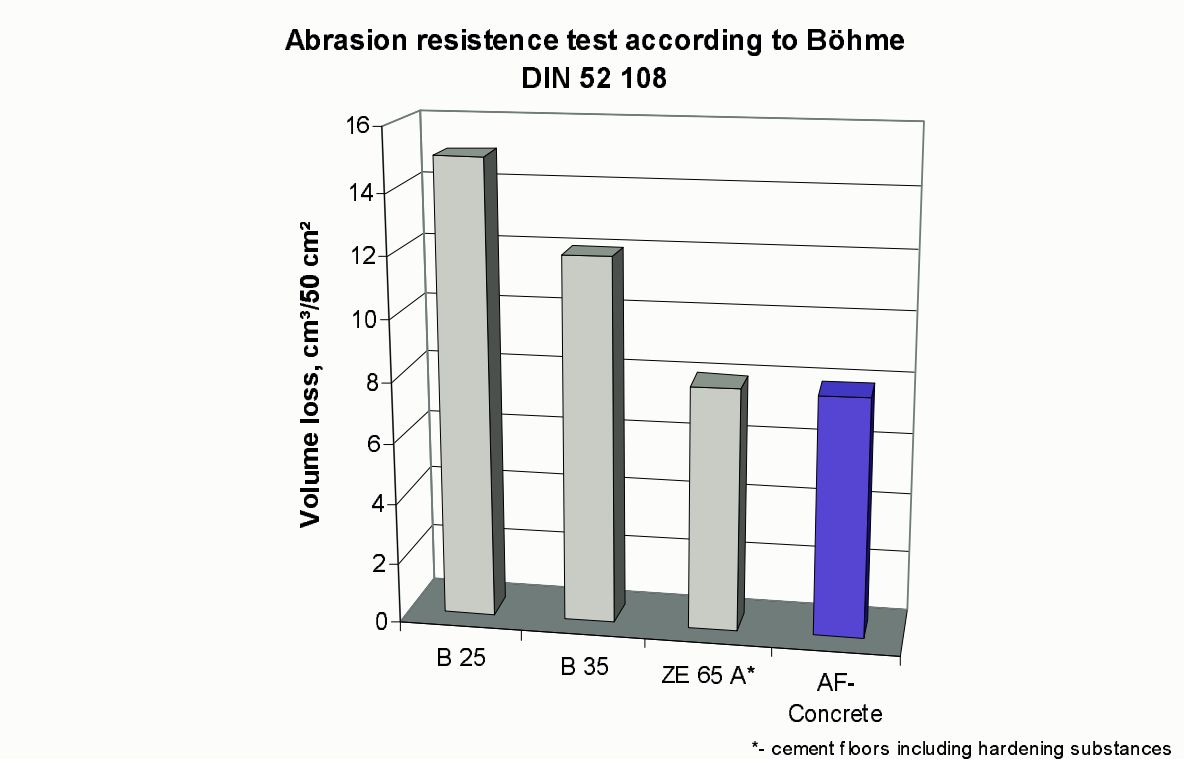

Diagram 2: Increase of resistance to abrasion

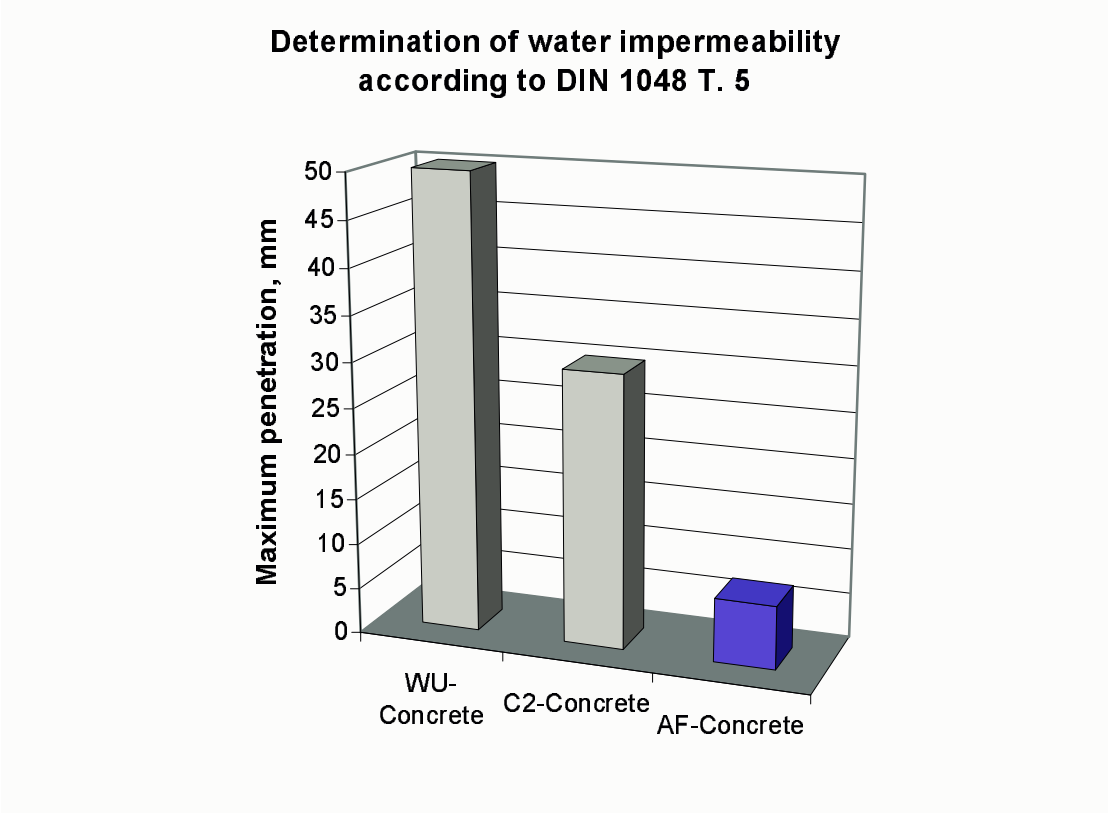

Diagram 3: Increase of water resistance

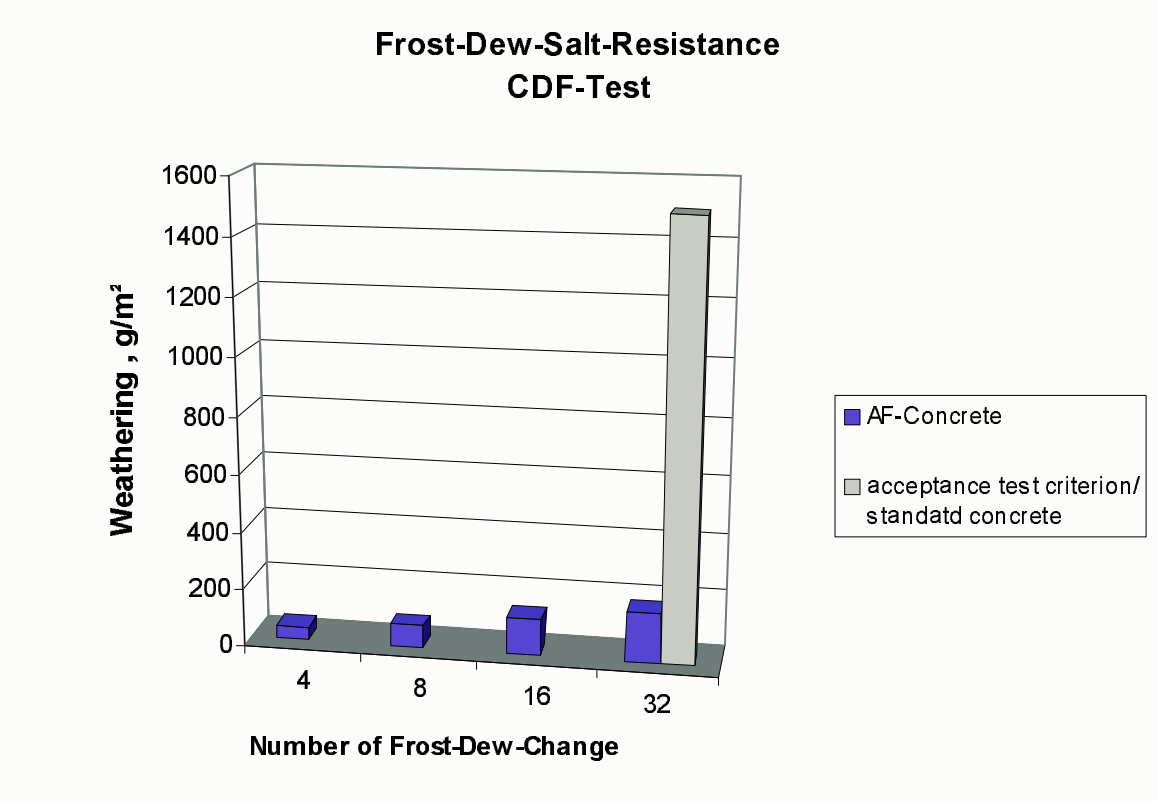

Diagram 4: Improvement resistance to frost and salty solution

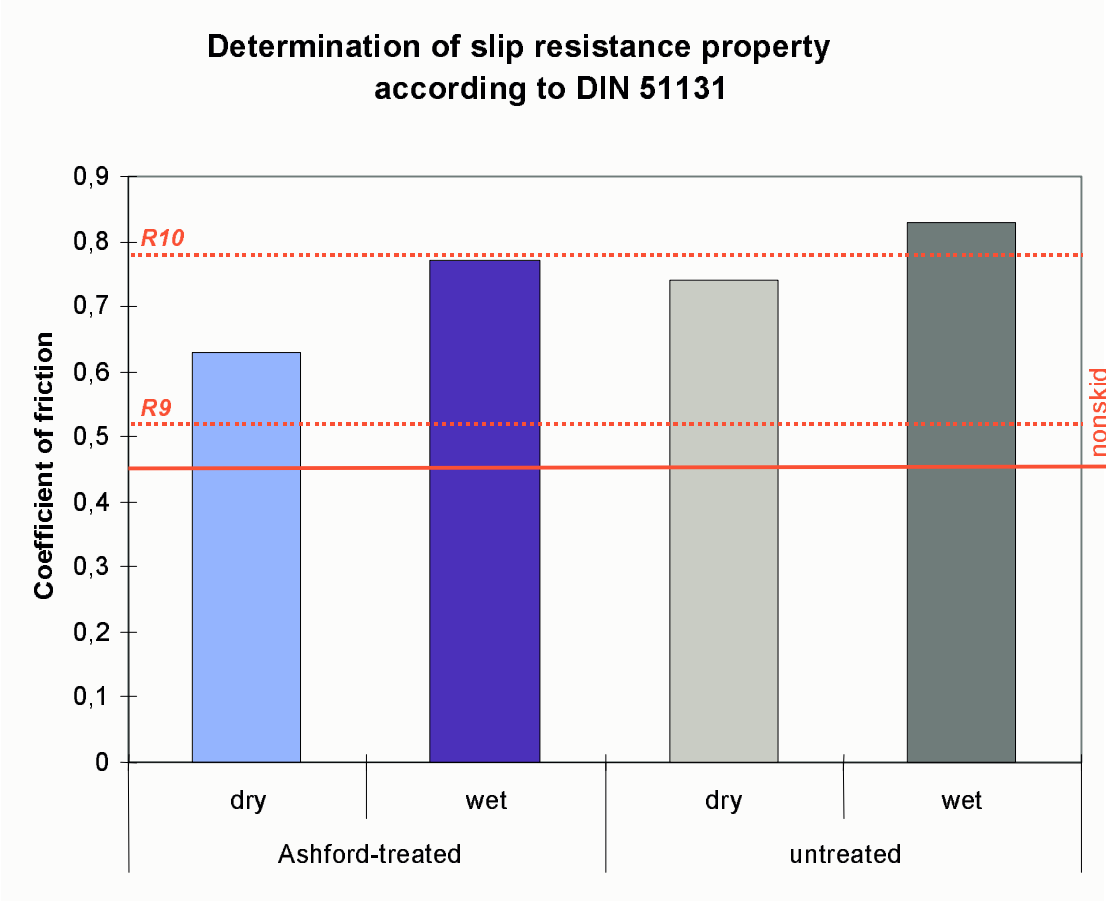

Diagram 5: Adherence

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