

## Test report no. 164162

English version

1<sup>st</sup> copy of 9 June 2017

Ordering party: Schomburg GmbH & Co. KG  
Aquafinstraße 2 - 8  
32760 Detmold

Date of commission: 02.03.2016 / Mr Beyer

Subject of commission: Tests regarding the efficiency of water resisting admixture  
for concrete

Product: BETOCRETE CP 360-WP

The test report contains 15 pages.

The testing material is used up.



Remark: This test report is the English version of original German version of 9 June 2017.

In case of any dispute the German version is decisive. The test report shall be published unabridged. Any partial publishing requires written allowance by the testing institute. The test results refer only to the tested material.

## 1. General

The ordering party has assigned MPA HANNOVER to perform tests regarding the efficiency of water resisting admixture for concrete in comparison to a reference concrete. The scope of the tests to be carried out has been determined by the ordering party and is set out in section 3. This test report states the results of the tests.

## 2. Delivery of samples

On 19 September 2016 by an employee of the ordering party:

250 kg Cement CEM I/52,5R typ „Milke Classic“ in 5 drums à 50 kg  
 5 kg BETOCRETE F4 (SP), in a canister, produced by Schomburg  
 1 kg BETOCRETE CP 360-WP, in a can, produced by Schomburg

The aggregate for manufacture the concrete was provided from the stock of MPA HANNOVER.

Weser sand 0/2  
 Weser gravel 2/8  
 Weser gravel 8/16

## 3. Scope

The scope of performed tests is listed in Table 1. The tests were performed each at the reference concrete (reference) and at the concrete produced with the water resisting admixture (CP 360-WP).

**Table 1:** Scope of testing

Test ID	Type of test	Standard	Age of sample	No. of samples
1	Bulk density of fresh concrete, Air content and Flow table test	DIN EN 12350-6:2011-03	20 min	1
		DIN EN 12350-7:2009-08	20 min	1
		DIN EN 12350-5:2009-08	5 min, 30 min	1
2	Compressive strength and bulk density	DIN EN 12390-3:2009-07	24 h, 7 d, 28 d	3
3	Deep of penetration of water under pressure	DIN EN 12390-8:2009-07	30 d	2
4	Freeze-thaw-salt resistance	BAW-Merkblatt „Frostprüfung von Beton“, 2012	28 d	5
5	Chloride migration resistance	BAW-Merkblatt „Chlorideindringwiderstand von Beton (MCL)“, 2012	56 d	3

## 4. Results

### 4.1 Manufacture of samples

The samples were produced according to DIN EN 12390-2:2009-08. A forced mixer Zyklos ZK 150 was used for the mixing. The mixing time was 2 min after water addition. The superplasticizer was added together with the water; the water resisting admixture was added separately. The water content of the admixtures was taken into account with 70 M.-% for the calculation. The compositions of mixtures are listed in Table 2. From this mixture, test specimens were prepared for the solid concrete tests, as well as the fresh concrete tests were carried out.

**Table 2:** Composition of mixtures

Raw material		Reference		CP 360-WP	
		Quantity	Mass kg/m <sup>3</sup>	Quantity	Mass kg/m <sup>3</sup>
Cement	-	-	350	-	350
Water	-	-	175	-	166
w/c-ratio	-	-	0.50	-	0.48
Sand 0-2 mm	M.-% of aggregate	35	630	35	636
Gravel 2-8 mm		30	526	30	542
Gravel 8-16 mm		35	627	35	634
Betocrete F 4 (SP)	M.-% of cement	0.7	2.45	0.7	2.45
Betocrete CP 360-WP		-	-	0.8	2.80

### 4.2 Bulk density of fresh concrete, air content and flow table test

The properties of fresh concrete were determined according to DIN EN 12350-5 (flow table test), DIN EN 12350-6 (bulk density) and 12350-7 (air content). The results are listed in Table 3.

**Table 3:** Results of test on fresh concrete

		Reference	CP 360-WP
Air temperature	°C	20	20
Flow table test A after water addition in mm	5 min	450	460
	30 min	370	370
Fresh concrete temperature	°C	22.1	20.6
Bulk density of fresh concrete	kg/dm <sup>3</sup>	2.35	2.32
Air content	Vol.- %	2.0	3.2

### 4.3 Compressive strength and bulk density

The determination of compressive strength were carried out 24 h, 7 days and 28 days after casting according to DIN EN 12390-3 at 3 cubes each with 150 mm edge length. The mean of the results are shown in Table 4. Details of the tests are listed in Appendix A1.

**Table 4:** Results of test of compressive strength according to DIN EN 12390-3, mean values

Mean value of samples	Age d	Reference		CP 360-WP	
		Bulk density kg/m <sup>3</sup>	Compressive strength f <sub>c,cube</sub> MPa	Bulk density kg/m <sup>3</sup>	Compressive strength f <sub>c,cube</sub> MPa
1-3	1	2300	16.4	2350	21.7
4-6	7	2330	48.2	2360	47.2
7-9	28	2320	57.9	2350	56.6

### 4.4 Deep of penetration of water under pressure

The deep of penetration of water were carried out according to DIN EN 12390-8 at 2 cubes each with the dimensions of 150 x 150 x 150 mm. The age of samples was 30 days at the begin of testing. The results of the tests are shown in Table 5. The spread of water at the cracking surfaces are shown in Appendix A2.

**Table 5:** Results of deep of penetration of water according to DIN EN 12390-8

Sample no.	Reference	CP 360-WP
	maximal deep of penetration mm	maximal deep of penetration mm
1	20	14
2	23	13
<i>Mean value</i>	22	14

### 4.5 Freeze-thaw-salt resistance

#### 4.5.1 Preparation for testing

The test of the freeze-thaw resistance was carried out according to BAW-Merkblatt „Frostprüfung von Beton“, version 2012. The samples were sawn, measured and prepared for testing, approximately 7 days before the start of the test. The lateral faces were sealed with solvent-free epoxy resin and glued with an aluminium foil with butyl bonding. The specimens were stored in a climate chamber at a temperature of 20 °C and a relative humidity of 65 % until testing. The weights of the specimens were determined before and after sealing of the lateral faces.



#### 4.5.2 Capillary suction

After preparing of the specimens and the pre-storage described above, the specimens were placed into the test containers on spacers with a height of 10 mm with the test surface facing the bottom. Then a test solution consisting of 3-percent sodium chloride solution was filled into the containers up to a height of 15 mm so that the specimens were immersed 5 mm deep into the test solution. The increase in weight of the test specimens was measured after two, five and seven days of storage in the test solution.

#### 4.5.3 Freeze-thaw testing

The test specimens together with the test containers and the present test liquid were placed into a temperature-controlled chest with liquid cooling bath and subjected to freeze-thaw testing according to the test specification mentioned in section 1. One freeze-thaw cycle lasts 12 hours. Beginning at + 20 °C, the temperature was lowered in 4 hours with a constant cooling rate to –20 °C. Then it was left to cool for 3 hours at this temperature and within 4 hours increased to +20 °C again and subsequently held for one hour. The specimens were taken from the chest in specific intervals and the water uptake, the surface scaling and the dynamic E-modulus were determined according to test specification. The results of the freeze-thaw test are compiled in Tables 6 as mean values. Details of the tests are listed in Appendix A3.

**Table 6:** Results of the test of Freeze-thaw-salt resistance, mean values

		Surface scaling in g/m <sup>2</sup>		rel. dyn. E-modulus in %	
		Reference	CP 360-WP	Reference	CP 360-WP
Frost-thaw cycle	0	0	0	100	100
	4	36	51	99	99
	10	167	180	94	98
	14	386	345	91	97
	18	1053	611	85	95
	24	2591	1215	73	96
	28	3680	1671	70	95

#### 4.6 Chloride migration resistance

The determination of the chloride migration resistance was performed according to BAW-Merkblatt „Chlorideindringwiderstand von Beton“, version 2012. The cubes were continuously stored under water after manufacturing. Cylinders with a diameter of 100 mm were drilled out from the samples approx. 7 days before testing. A layer of 10 mm was removed from the upper edge by sawing. A test area parallel saw cut was made at a height of approx.  $50 \pm 5$  mm measured from the test surface. The test specimens were stored in a water bath at 20 °C until testing and were installed and tested in migration cells at the start of the test. The chloride migration coefficients calculated from the test results shown in Appendix A4 are shown in Table 7. For comparison, the normatively required coefficients are given in Table 8.

**Table 7:** Chloride migration coefficients

Probe	Chloride migration coefficient $\times 10^{-12}$ [m <sup>2</sup> /s]	
	Reference	CP 360-WP
1	17.8	11.3
2	14.0	9.8
3	12.2	7.9
<i>Mean value <math>D_{CL}</math></i>	14.7	9.7
<i>Max. individual value <math>D_{CL,max}</math></i>	17.8	11.3

Depending on the given exposure class, the mean values and maximum individual values of migration coefficients given in Table 8 must be complied with in accordance with BAW-Merkblatt "Chlorideindringwiderstand von Beton", version 2012.

**Table 8:** Mean values to be complied with and the maximum permissible individual values of the migration coefficients as a function of the exposure class

Given exposure class acc. DIN EN 206-1 /DIN 1045-2	Migration coefficient	
	Mean value $\times 10^{-12}$ [m <sup>2</sup> /s]	<i>Max. individual value</i> $\times 10^{-12}$ [m <sup>2</sup> /s]
-		
XS 1, XD 1	$\leq 10.0$	$\leq 12.0$
XS 2, XD 2		
XS 3, XD 3	$\leq 5.0$	$\leq 7.0$

Hanover, 9 June 2017  
Head of Testing Institute

(ORR Dr.-Ing. H. Höveling)



Contact

(Dipl.-Ing. A. Giese)

## APPENDIX

### Appendix A1: Test of compressive strength

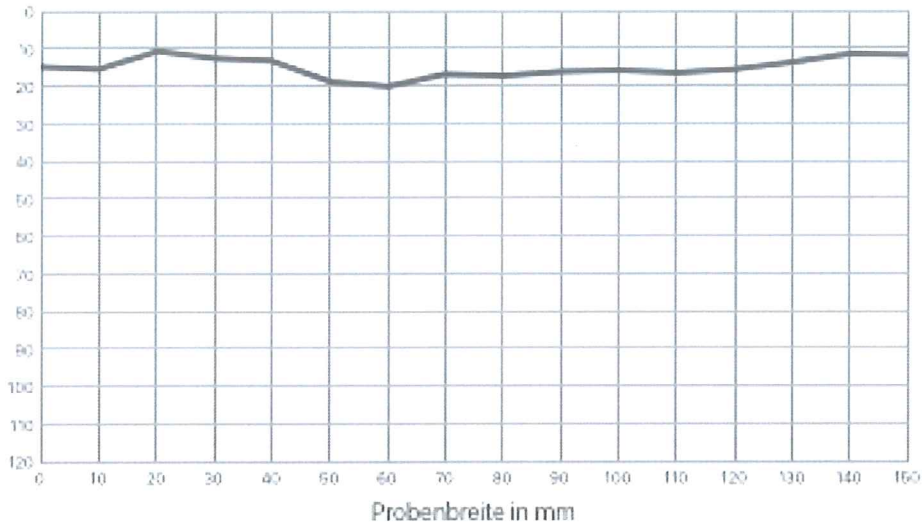
#### Appendix A1-1: Results of test of compressive strength according to DIN EN 12390-3, reference

Date of casting:								12.10.2016	
Sample no.	Dimensions			Age d	Mass kg	Bulk density kg/m <sup>3</sup>	max. load F kN	Compressive strength	
	Length mm	Width mm	Height mm					f <sub>c,dry</sub> N/mm <sup>2</sup>	f <sub>c,cube</sub> N/mm <sup>2</sup>
1	150	152	150	1	7.88	2310	379	-	16.7
2	150	151	150		7.78	2290	363	-	16.1
3	150	150	150		7.80	2310	372	-	16.5
<i>Mean:</i>						2300	-	-	16.4
4	150	150	150	7	7.87	2340	1101	-	48.9
5	150	152	150		7.93	2330	1083	-	47.7
6	150	150	150		7.84	2330	1077	-	48.0
<i>Mean:</i>						2330	-	-	48.2
7	150	151	150	28	7.85	2320	1405	62.1	57.2
8	150	150	150		7.81	2320	1438	64.0	58.9
9	150	152	150		7.89	2310	1429	62.6	57.6
<i>Mean:</i>						2320	-	62.9	57.9

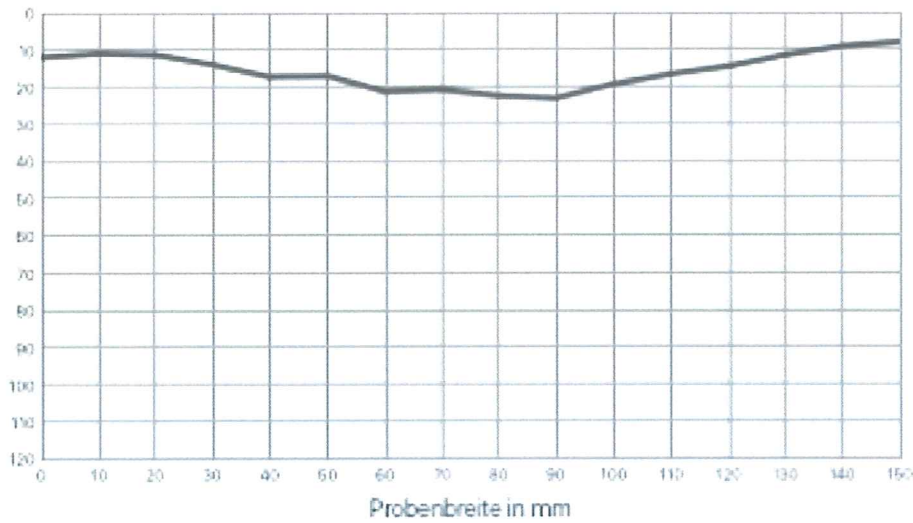
#### Appendix A1-2: Results of test of compressive strength according to DIN EN 12390-3, CP 360-WP

Date of casting:								12.04.2017	
Sample no.	Dimensions			Age d	Mass kg	Bulk density kg/m <sup>3</sup>	max. load F kN	Compressive strength	
	Length mm	Width mm	Height mm					f <sub>c,dry</sub> N/mm <sup>2</sup>	f <sub>c,cube</sub> N/mm <sup>2</sup>
1	150	152	150	1	8.01	2350	508	-	22.3
2	150	152	150		8.04	2360	495	-	21.7
3	150	152	150		8.02	2350	482	-	21.2
<i>Mean:</i>						2350	-	-	21.,7
4	150	152	150	7	8.03	2360	1071	-	47.1
5	150	150	150		8.00	2370	1076	-	47.8
6	150	152	150		8.09	2360	1067	-	46.7
<i>Mean:</i>						2360	-	-	47.2
7	150	151	150	28	7.92	2340	1411	62.5	57.5
8	150	149	150		7.92	2360	1390	62.1	57.1
9	150	150	150		7.90	2350	1348	60.1	55.3
<i>Mean:</i>						2350	-	61.6	56.6

**Appendix A2: Deep of penetration of water**

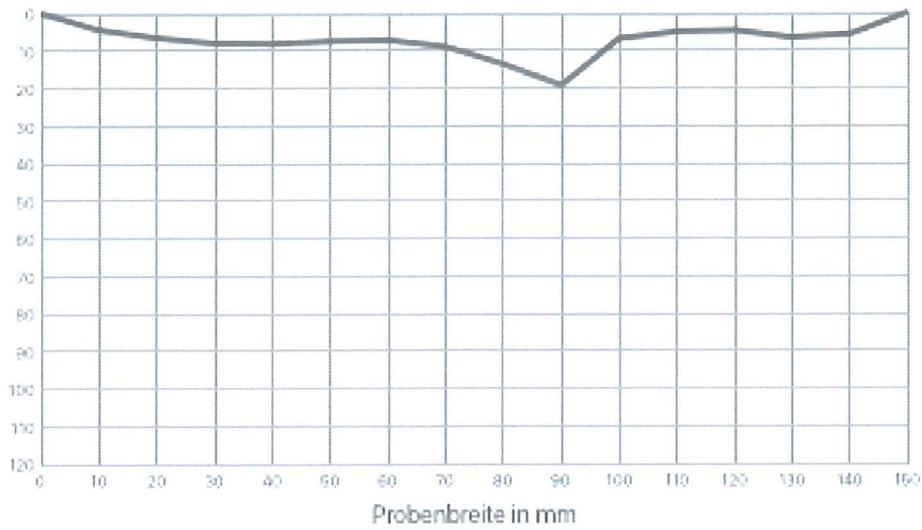


**Appendix A2-1: Deep of penetration of water, reference: 1, max. deep of penetration  $t = 20$  mm**

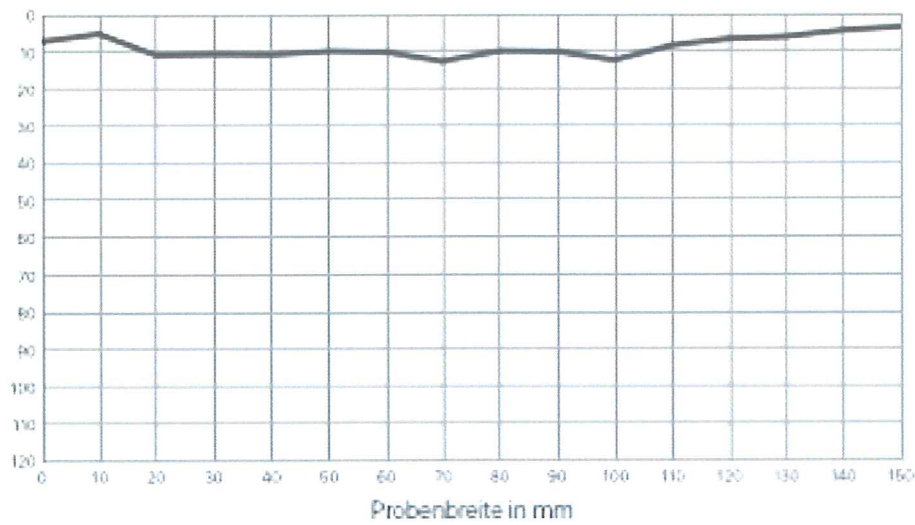


**Appendix A2-2: Deep of penetration of water, reference: 2, max. deep of penetration  $t = 23$  mm**





**Appendix A2-3:** Deep of penetration of water, CP 360-WP: 1, max. deep of penetration  $t = 14$  mm (Outliers at 19 mm not rated)



**Appendix A2-4:** Deep of penetration of water, CP 360-WP: 2, max. deep of penetration  $t = 13$  mm

### Appendix A3: Freeze-thaw-salt testing

#### Appendix A3-1: Dimensions and mass for specimen preparation, reference

Specimen			1	2	3	4	5
Weight	without belt	g	2703	2736	2802	2788	2787
	with belt		2803	2819	2900	2890	2889
Dimensions w/o sealing	Length	mm	151	150	152	152	151
	Width		108	111	111	111	111
	Height		72	72	72	72	72

#### Appendix A3-2: Water uptake, reference

Begin of test:									09.11.2016
Probe	after d		1	2	3	4	5	Mean	Standard deviation
Capillary suction in d	-7	M.- %	-0.68	-0.88	-0.78	-0.67	-0.74	-0.75	0.09
	-5		-0.20	-0.26	-0.21	-0.18	-0.19	-0.21	0.03
	-2		-0.06	-0.08	-0.06	-0.06	-0.05	-0.06	0.01
	0		0.00	0.00	0.00	0.00	0.00	0.00	0.00
Frost-thaw cycle	4		0.15	0.22	0.19	0.16	0.18	0.18	0.03
	10		0.53	0.69	0.59	0.53	0.62	0.59	0.07
	14		0.82	1.04	0.89	0.80	0.90	0.89	0.09
	18		1.12	1.23	1.15	1.05	1.15	1.14	0.06
	24		1.36	1.25	0.90	1.58	1.25	1.27	0.24
	28		1.42	1.35	0.91	1.63	1.29	1.32	0.26

#### Appendix A3-3: Relative dynamic E-modulus of the specimens, reference

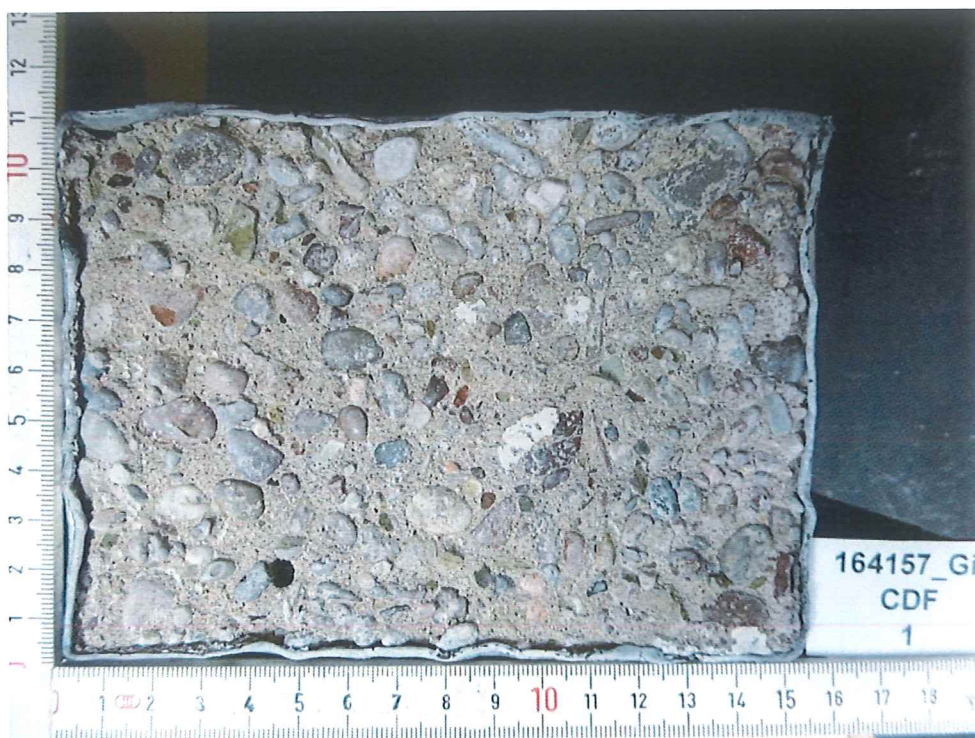
Frost-thaw cycle	Relative dynamic E-modulus in %						
	1	2	3	4	5	Mean	Standard deviation
0	100	100	100	100	100	100	0
4	98	99	98	100	98	99	1
10	95	94	95	94	93	94	1
14	92	91	90	92	91	91	1
18	87	86	82	85	84	85	2
24	78	79	76	58	77	73	9
28	74	71	73	64	69	70	4

#### Appendix A3-4: Surface scaling of the specimens by weathering, reference

Frost-thaw cycle	Surface scaling in g/m <sup>2</sup>						
	1	2	3	4	5	Mean	Standard deviation
0	0	0	0	0	0	0	0
4	30	35	41	33	42	36	5
10	160	165	166	143	202	167	22
14	334	402	400	305	491	386	72
18	847	1141	1110	785	1380	1053	241
24	2319	2741	2455	2448	2990	2591	271
28	3373	3872	3519	3604	4030	3680	267
95 % - quantile after 28 frost-thaw cycles						4294	



Appendix A3-5: Sample before testing, reference



Appendix A3-6: Sample after testing, reference



**Appendix A3-7:** Dimensions and mass for specimen preparation, CP 360-WP

Specimen			1	2	3	4	5
Weight	without belt	g	2655	2699	2600	2541	2666
	with belt		2693	2683	2797	2684	2706
Dimensions w/o sealing	Length	mm	150	150	150	150	150
	Width		109	110	110	108	109
	Height		72	72	69	70	72

**Appendix A3-8:** Water uptake, CP 360-WP

Begin of test:									23.11.2016
Probe	after d		1	2	3	4	5	Mean	Standard deviation
Capillary suction in d	-7	M.- %	-0.61	-0.57	-0.69	-0.72	-0.67	-0.65	0.06
	-5		-0.16	-0.11	-0.14	-0.16	-0.13	-0.14	0.02
	-2		-0.05	-0.02	-0.03	-0.04	-0.03	-0.03	0.01
	0		0.00	0.00	0.00	0.00	0.00	0.00	0.00
Frost-thaw cycle	4		0.18	0.19	0.17	0.17	0.17	0.18	0.01
	10		0.46	0.41	0.38	0.40	0.38	0.41	0.03
	14		0.59	0.57	0.56	0.58	0.51	0.56	0.03
	18		0.71	0.72	0.67	0.67	0.61	0.68	0.05
	24		0.91	0.95	0.82	0.82	0.79	0.86	0.07
	28		1.03	1.16	0.51	0.96	0.88	0.91	0.24

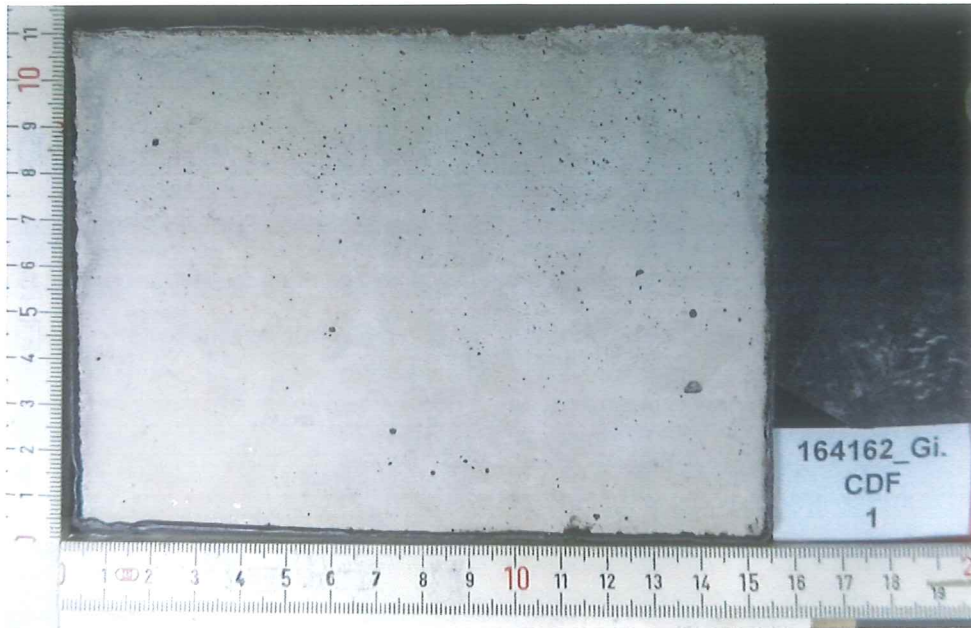
**Appendix A3-9:** Relative dynamic E-modulus of the specimens, CP 360-WP

Frost-thaw cycle	Relative dynamic E-modulus in %						
	1	2	3	4	5	Mean	Standard deviation
0	100	100	100	100	100	100	0
4	98	100	99	99	99	99	0
10	98	98	98	98	98	98	0
14	97	96	96	98	97	97	1
18	97	94	97	91	96	95	3
24	93	96	97	98	96	96	2
28	90	95	98	97	95	95	3

**Appendix A3-10:** Surface scaling of the specimens by weathering, CP 360-WP

Frost-thaw cycle	Surface scaling in g/m <sup>2</sup>						
	1	2	3	4	5	Mean	Standard deviation
0	0	0	0	0	0	0	0
4	47	44	45	65	51	51	9
10	177	161	162	236	161	180	32
14	350	299	328	450	296	345	63
18	633	523	593	798	506	611	117
24	1291	1024	1229	1531	1002	1215	217
28	1902	1575	1259	2127	1490	1671	344
95 % - quantile after 28 frost-thaw cycles						2462	---





Appendix A3-11: Sample before testing, CP 360-WP



Appendix A3-12: Sample after testing, CP 360-WP

## Appendix A4: Chloride migration

### Appendix A4-1: Measured values of the test, reference

Sample no.	Test start		Test end		Amperage start	Amperage end	Duration of test
	Date	Time	Date	Time	mA	mA	h
1	08.12.16	11:55	08.12.16	19:50	79.0	73.2	7.92
2	08.12.16	11:55	08.12.16	19:50	69.0	67.3	7.92
3	08.12.16	11:55	08.12.16	19:50	73.5	70.1	7.92

Sample no.	Test liquid		Test sample				
	Temperature		Height	Diameter	Mass after		Bulk density Water storage
	Start	End			Water storage	Testing	
°C	°C	mm	mm	g	g	[kg/m <sup>3</sup> ]	
1	19.5	19.7	49.95	99.51	911.86	-	2350
2	19.6	19.7	51.25	99.46	914.34	-	2300
3	19.7	19.7	50.58	99.48	918.58	-	2340

Penetration depths:							
[mm]	Sample 1 half 1	Sample 1 half 2	Sample 2 half 1	Sample 2 half 2	Sample 3 half 1	Sample 3 half 2	
Point 1	18.67	13.72	14.06	12.93	14.08	12.26	
Point 2	18.07	12.60	11.02	11.26	10.27	12.26	
Point 3	17.57	12.13	10.40	10.35	9.22	9.32	
Point 4	17.48	11.52	12.33	10.59	8.30	10.53	
Point 5	10.38	12.07	10.50	12.96	9.18	9.30	
Point 6	11.16	13.36	10.50	17.09	10.99	11.14	
Point 7	13.16	13.41	12.14	11.25	9.86	11.71	
Point 8	13.23	14.01	9.57	9.83	8.36	9.92	
Point 9	21.58	10.65	11.14	8.33	9.88	9.03	
Point 10	17.85	14.76	10.20	7.85	10.63	8.78	
Point 11	14.76	11.07	12.39	16.64	11.89	10.08	
<b>Mean value <math>x_d</math></b>	15.23	12.87	10.87	11.06	9.63	9.97	
<b>Max. value <math>x_{max}</math></b>	18.67	14.76	12.39	17.09	11.89	12.26	

Remark: Blue values were not included in the evaluation!



Appendix A4-2: Samples after testing, reference



**Appendix A4-3: Measured values of the test, CP 360-WP**

Sample no.	Test start		Test end		Amperage start	Amperage end	Duration of test
	Date	Time	Date	Time	mA	mA	h
1	19.12.16	09:15	19.12.16	17:15	65.1	57.4	8.00
2	19.12.16	09:15	19.12.16	17:15	63.5	55.6	8.00
3	19.12.16	09:15	19.12.16	17:15	63.5	56.8	8.00

Sample no.	Test liquid		Height	Diameter	Test sample		Bulk density Water storage [kg/m³]
	Temperature				Mass after		
	Start	End	Water storage	Testing			
	°C	°C	mm	mm	g	g	
1	20.6	20.9	49.49	99.43	868.87	869.83	2260
2	20.6	20.7	49.44	99.59	866.14	806.02	2250
3	20.6	20.8	50.01	99.08	868.22	867.54	2250

**Penetration depths:**

[mm]	Sample 1 half 1	Sample 1 half 2	Sample 2 half 1	Sample 2 half 2	Sample 3 half 1	Sample 3 half 2
Point 1	11.39	11.01	15.89	14.17	12.51	12.69
Point 2	9.61	7.05	7.71	9.90	9.91	9.32
Point 3	7.69	7.34	6.75	8.37	7.53	7.94
Point 4	7.69	7.42	7.65	7.57	5.29	7.56
Point 5	9.84	8.87	10.80	5.76	5.33	6.85
Point 6	10.51	10.32	10.19	6.63	4.67	6.72
Point 7	9.92	10.37	6.59	9.72	6.79	6.49
Point 8	11.75	11.61	8.30	6.76	6.92	6.61
Point 9	9.04	10.37	8.35	7.04	6.59	5.42
Point 10	9.04	10.08	10.49	9.85	7.24	5.69
Point 11	10.68	13.13	13.02	14.48	10.34	5.81
<b>Mean value <math>x_d</math></b>	9.45	9.27	8.54	7.96	6.70	6.84
<b>Max. value <math>x_{max}</math></b>	11.75	11.61	10.80	9.90	9.91	9.32

Remark: Blue values were not included in the evaluation!



**Appendix A4-4: Samples after testing, CP 360-WP**