



## Istituto Meccanica dei Materiali SA

via al Molino 6 - 6916 Grancia - Switzerland  
Tel. +41 91 994.83.41 - Fax +41 91 994.85.30  
E-mail: imm@imm.ch - Web: www.imm.ch

# SUMMARY SHEET FOR TESTING PROGRAM ON PENETRON ADMIX

## PROJECT'S TITLE:

### EFFECT OF PENETRON ON

#### • RESISTANCE TO CARBONATION

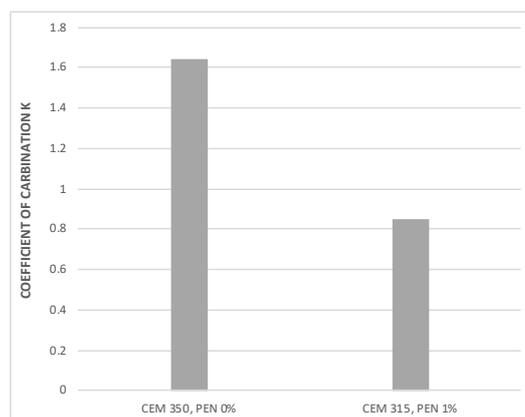
**SCOPE:** to compare the performance of a prescribed mix by BS8500 (BS EN 206:2013) for 50-year service life with severe exposure to carbonation to an economic mix containing 1% of Penetron by mass of cementitious materials. The mix with Penetron contains less 10% cement and has a higher water content (i.e. requires less admixture) than the prescribed mix.

**METHOD:** comparing a prescribed mix with given W/C (0.43) and given dosage of cement (350 kg/m<sup>3</sup>) with a mix containing 315 kg/m<sup>3</sup> of cement, 1% Penetron by weight of cementitious materials, and W/C = 0.48.

#### MATERIALS:

- CEM I 52.5N (EN 197-1), CEM IV/B-V 42.5 (EN 197-1, aka Fly Ash cement)
- Penetron admix
- Aggregates: 32 mm max aggregate size
- Admixture: Superplasticizer Type F/G of ASTM C494

#### SUMMARY CHARTS:



#### COMMENTS TO RESULTS:

- The addition of 1% Penetron admix to an economic mix with less cement and more water than the prescribed mix by BS 8500 allows for almost 50% increase of the resistance to carbonation.

#### SUGGESTED TECHNICAL ARGUMENTS:

- Using Penetron admix for casting concrete structures above water exposed to wet/dry cycles and carbonation (exposure to rain in polluted environments) can extend service life and/or allow reduction of concrete cover.



## ACCELERATED CARBONATION TEST

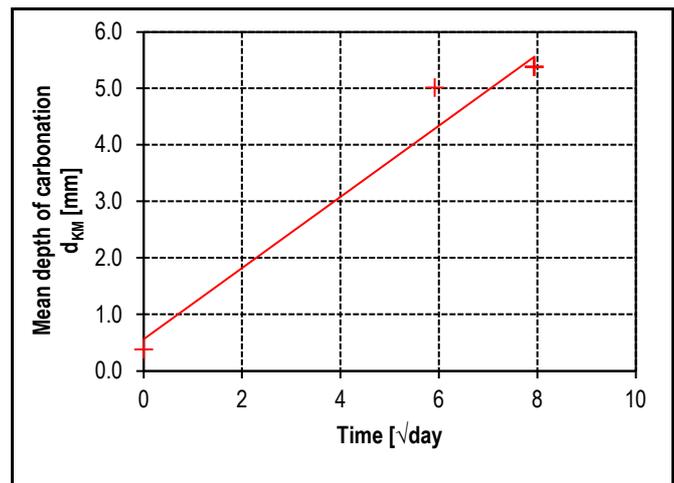
**Client:** Penetron International

**Project:** Durability testing program - carbonation - CONTROL MIX  
**Structure:** --  
**Section:** --  
**Casting:** Carried out by IMM; control on 08.08.2019 time 09:30

**Classification:** – BS 8500-1 XC4, Ø 32 mm  
**Cement:** CEM IV B-V (FLY ASH CEMENT) – 350 kg/m<sup>3</sup>  
**Admixture 1:** ASTM C494 TYPE F/G – 1 %  
**Admixture 2:** --  
**Admixture 3:** --  
**Aggregates** { **Grading:** 0/32 (100%) -- -- --  
} **Origin:** -- -- -- --  
**Supplying:** Mobile plant Laboratory pan mixer **Delivery:** --  
**Fresh concr. test report:** --  
**Fresh concr. properties:** Bulk density: 2402 kg/m<sup>3</sup>; Water content: 168 kg/m<sup>3</sup>;  
 Slump test: 240 mm; Water/cement ratio: 0.43

**Starting date of curing:** -- **Nominal size:** Prism (120x120x360) mm  
**Starting date of testing:** 05.09.2019 **Age at starting date:** 28 days  
**Climatic chamber:** T = 20±2 °C, RH\* = 57±3%, CO<sub>2</sub> ≤ 0.15% vol  
**Carbonation chamber:** T = 20±2 °C, RH = 57±3%, CO<sub>2</sub> = 4.0±0.1% vol  
**Technician:** Tec. M. Somazzi

Time [days]	$d_{KE}$ [mm]				$d_{KM}$ [mm]
	Side A	Side B	Side C	Side D	
0	0.4	0.4	0.4	0.4	0.4
35	5.0	5.3	4.6	5.1	5.0
63	4.7	5.3	5.4	6.1	5.4
Constant A [mm]					0.565
Coefficient $K_S$ [mm/√day]					0.629
Correction factor c [-]					1.36
<b>Carbonation Coefficient <math>K_N</math> [mm/√year]</b>					<b>1.64</b>



Remarks:

Grancia, 29.11.2019 General Manager: Dott. M. Di Tommaso

*M. Di Tommaso*



**IMM**

Istituto Meccanica dei Materiali SA

Via al Molino 55 - 6916 Grancia - Switzerland  
T +41 91 994 83 41 E-mail imm@imm.ch  
F +41 91 994 85 30 Web www.imm.ch

Test report:

**CRA11374C**

Standard: CEN METHOD

Page 2/2

## ACCELERATED CARBONATION TEST

**Client:** Penetron International

**Project:** Durability testing program - carbonation - CONTROL MIX

**Structure:** --

**Section:** --

**Casting:** Carried out by IMM; control on 08.08.2019 time 09:30

**Classification:** – BS 8500-1 XC4, Ø 32 mm

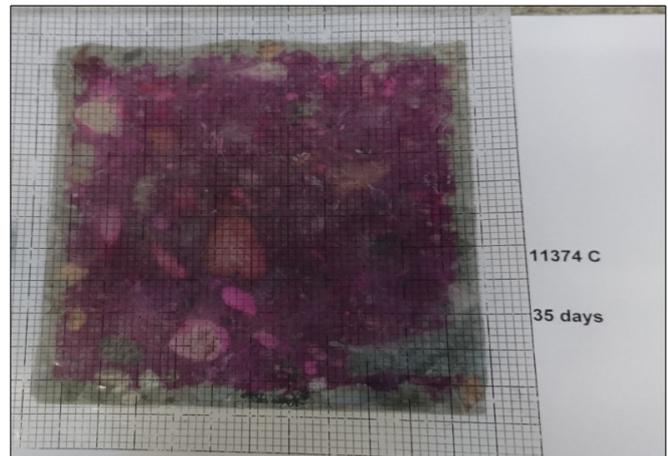
**Nominal size:** Prism (120x120x360) mm

**Starting date of testing:** 05.09.2019

### PHOTOGRAPHIC DOCUMENTATION



Carbonation degree at the beginning of test



Carbonation degree after 35 days



Carbonation degree after 63 days



Carbonation degree after 154 days



## ACCELERATED CARBONATION TEST

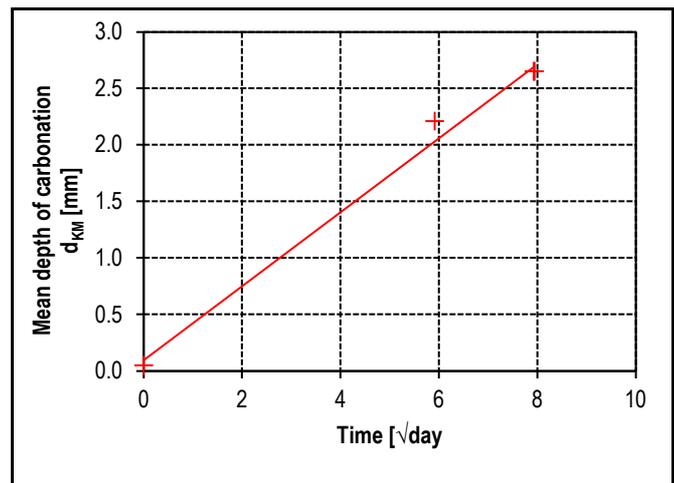
**Client:** Penetron International

**Project:** Durability testing program - carbonation - PENETRON MIX  
**Structure:** --  
**Section:** --  
**Casting:** Carried out by IMM; control on 08.08.2019 time 10:20

**Classification:** – BS 8500-1 XC3, Ø 32 mm  
**Cement:** CEM I 52.5 (OPC TYPE I) – 315 kg/m<sup>3</sup>  
**Admixture 1:** ASTM C494 TYPE F/G – 1 %  
**Admixture 2:** Penetron – Admix ® – 1 %  
**Admixture 3:** --  
**Aggregates** { **Grading:** 0/32 (100%) -- -- --  
} **Origin:** -- -- -- --  
**Supplying:** Mobile plant Laboratory pan mixer **Delivery:** --  
**Fresh concr. test report:** --  
**Fresh concr. properties:** Bulk density: 2358 kg/m<sup>3</sup>; Water content: 167 kg/m<sup>3</sup>;  
 Slump test: 240 mm; Water/cement ratio: 0.48

**Starting date of curing:** -- **Nominal size:** Prism (120x120x360) mm  
**Starting date of testing:** 05.09.2019 **Age at starting date:** 28 days  
**Climatic chamber:** T = 20±2 °C, RH\* = 57±3%, CO<sub>2</sub> ≤ 0.15% vol  
**Carbonation chamber:** T = 20±2 °C, RH = 57±3%, CO<sub>2</sub> = 4.0±0.1% vol  
**Technician:** Tec. M. Somazzi

Time [days]	$d_{KE}$ [mm]				$d_{KM}$ [mm]
	Side A	Side B	Side C	Side D	
0	0.0	0.1	0.1	0.1	0.1
35	2.5	2.2	2.0	2.1	2.2
63	2.5	2.9	2.7	2.5	2.7
Constant A [mm]					0.095
Coefficient $K_S$ [mm/√day]					0.327
Correction factor c [-]					1.36
<b>Carbonation Coefficient <math>K_N</math> [mm/√year]</b>					<b>0.85</b>



Remarks:

Grancia, 29.11.2019 General Manager: Dott. M. Di Tommaso

*M. Di Tommaso*

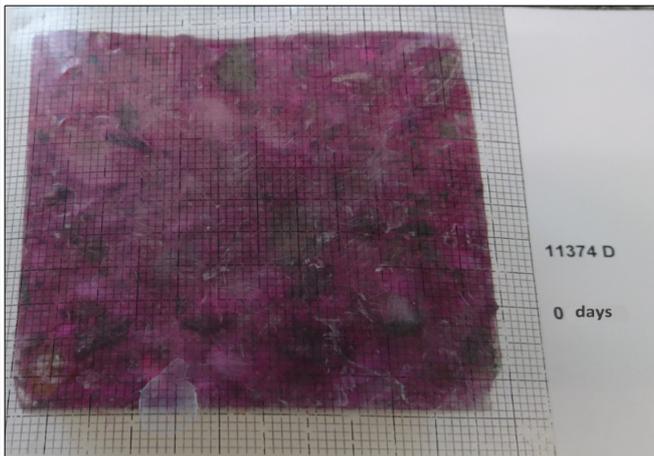


## ACCELERATED CARBONATION TEST

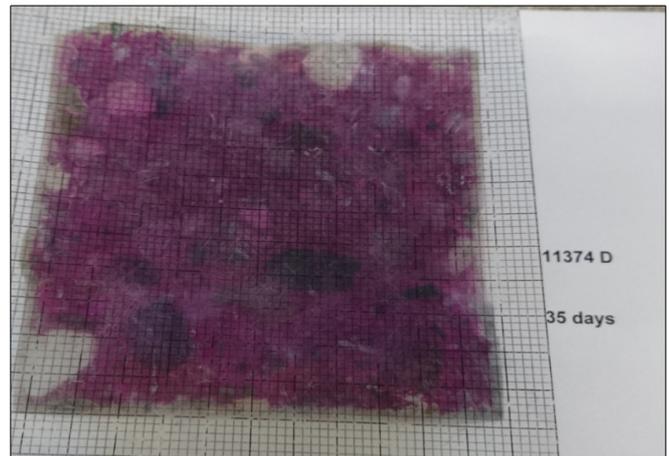
**Client:** Penetron International  
**Project:** Durability testing program - carbonation - PENETRON MIX  
**Structure:** --  
**Section:** --  
**Casting:** Carried out by IMM; control on 08.08.2019 time 10:20

**Classification:** – BS 8500-1 XC3, Ø 32 mm  
**Nominal size:** Prism (120x120x360) mm  
**Starting date of testing:** 05.09.2019

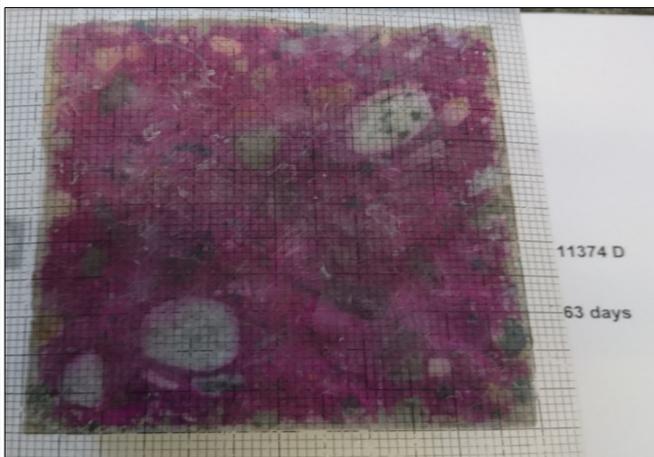
### PHOTOGRAPHIC DOCUMENTATION



Carbonation degree at the beginning of test



Carbonation degree after 35 days



Carbonation degree after 63 days



Carbonation degree after 154 days



## ACCELERATED CARBONATION TEST

**Client:** Penetron International

**Project:** Durability testing program - carbonation - CONTROL MIX WITH PENETRON

**Structure:** --

**Section:** --

**Casting:** Carried out by IMM; control on 08.08.2019 time 11:00

**Classification:** – BS 8500-1 XC4, Ø 32 mm

**Cement:** CEM IV B-V (FLY ASH CEMENT) – 350 kg/m<sup>3</sup>

**Admixture 1:** ASTM C494 TYPE F/G – 1 %

**Admixture 2:** Penetron – Admix ® – 1 %

**Admixture 3:** --

Aggregates	Grading:	0/32 (100%)	--	--	--
	Origin:	--	--	--	--

**Supplying:** Mobile plant Laboratory pan mixer      **Delivery:** --

**Fresh concr. test report:** --

**Fresh concr. properties:** Bulk density: 2369 kg/m<sup>3</sup>; Water content: 168 kg/m<sup>3</sup>;  
 Slump test: 240 mm; Water/cement ratio: 0.43

**Starting date of curing:** --      **Nominal size:** Prism (120x120x360) mm

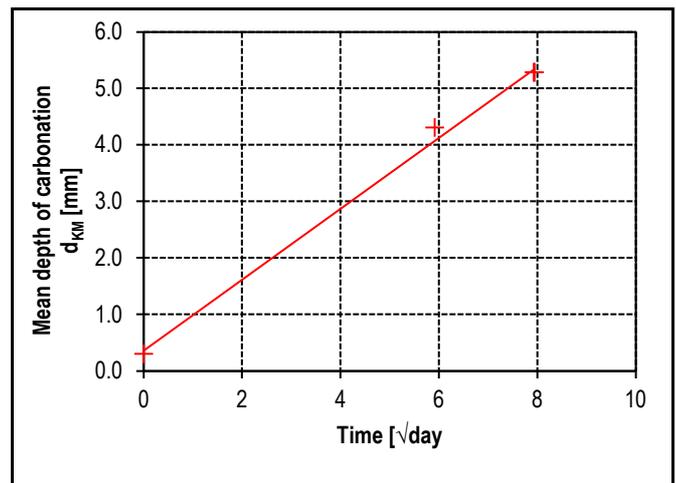
**Starting date of testing:** 05.09.2019      **Age at starting date:** 28 days

**Climatic chamber:** T = 20±2 °C, RH\* = 57±3%, CO<sub>2</sub> ≤ 0.15% vol

**Carbonation chamber:** T = 20±2 °C, RH = 57±3%, CO<sub>2</sub> = 4.0±0.1% vol

**Technician:** Tec. M. Somazzi

Time [days]	$d_{KE}$ [mm]				$d_{KM}$ [mm]
	Side A	Side B	Side C	Side D	
0	0.4	0.4	0.2	0.3	0.3
35	3.7	4.4	4.5	4.7	4.3
63	5.2	5.5	5.4	5.1	5.3
Constant A [mm]					0.360
Coefficient $K_S$ [mm/√day]					0.628
Correction factor c [-]					1.36
<b>Carbonation Coefficient <math>K_N</math> [mm/√year]</b>					<b>1.63</b>



Remarks:

Grancia, 29.11.2019      General Manager: Dott. M. Di Tommaso

*M. Di Tommaso*



## ACCELERATED CARBONATION TEST

**Client:** Penetron International

**Project:** Durability testing program - carbonation - CONTROL MIX WITH PENETRON

**Structure:** --

**Section:** --

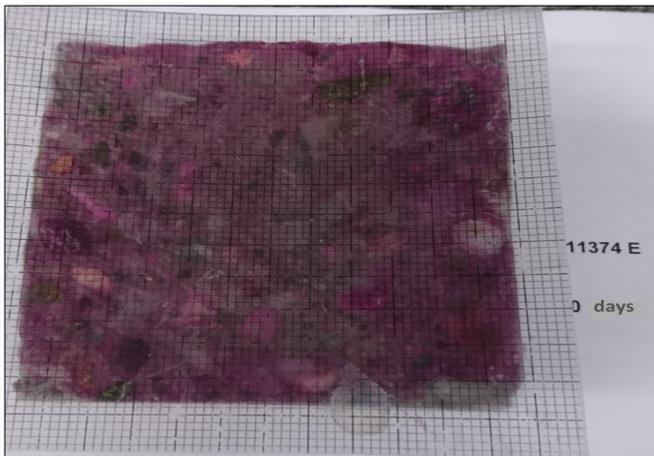
**Casting:** Carried out by IMM; control on 08.08.2019 time 11:00

**Classification:** – BS 8500-1 XC4, Ø 32 mm

**Nominal size:** Prism (120x120x360) mm

**Starting date of testing:** 05.09.2019

### PHOTOGRAPHIC DOCUMENTATION



**Carbonation degree at the beginning of test**



**Carbonation degree after 35 days**



**Carbonation degree after 63 days**



**Carbonation degree after 154 days**



## Istituto Meccanica dei Materiali SA

via al Molino 6 - 6916 Grancia - Switzerland  
Tel. +41 91 994.83.41 - Fax +41 91 994.85.30  
E-mail: imm@imm.ch - Web: www.imm.ch

### SUMMARY SHEET FOR TESTING PROGRAM ON PENETRON ADMIX

#### PROJECT'S TITLE:

#### EFFECT OF PENETRON ON

#### • COEFFICIENT ALFA OF THE INCREASE OF RESISTANCE TO CHLORIDE

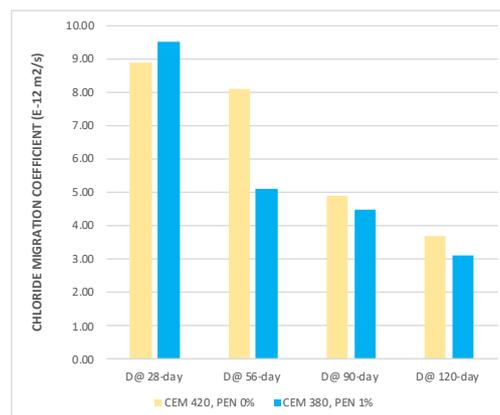
**SCOPE:** to compare whether an economic fly-ash mix compared to a prescribed fly-ash mix by BS 8500 (BS EN 206-1:2013) for exposure to marine environment for 50- year service life could display a higher alfa coefficient than what is utilized in durability design for fly-ash concrete. The alfa coefficient for fly-ash concrete is taken to be 0.60 by FIB 34. The economic mix contains less 10% of cement and higher water content: 0.48 of the economic mix versus 0.43 of the prescribed mix.

**METHOD:** measuring the resistance to chloride at 28-day, 56-day, 90-day and 120-day to calculate the alfa coefficient for the economic mix containing 1% Penetron by mass of cementitious materials

#### MATERIALS:

- CEM II/B-V 42.5 (EN 197-1, aka Fly Ash cement)
- Penetron admix
- Aggregates: 16 mm max aggregate size
- Admixture: Superplasticizer Type F/G of ASTM C494

#### SUMMARY CHARTS:



#### COMMENTS TO RESULTS:

- The addition of 1% Penetron admix to an economic mix with less cement and more water than the prescribed mix by BS 8500 allows to calculate an alfa coefficient of 0.75 which is sensibly higher than the value utilized for durability design. This has an impact on service life and probability of corrosion.



**SUGGESTED TECHNICAL ARGUMENTS:**

- The rate of improvement of resistance to chloride for an economic mix containing 1% Penetron is higher than the rate of improvement of a prescribed mix by BS 8500 with implications for extension of service life and probability of corrosion.

**IMM**

Istituto Meccanica dei Materiali SA

Via al Molino 55 - 6916 Grancia - Switzerland  
T +41 91 994 83 41 E-mail imm@imm.ch  
F +41 91 994 85 30 Web www.imm.ch

Test report:

**CLO11374F**

Standard: SIA 262/1-B

**RESISTANCE TO CHLORIDE PENETRATION****Client:** Penetron International**Project:** Durability testing program - chlorides - CONTROL MIX**Structure:** --**Section:** --**Casting:** Carried out by IMM; control on 21.08.2019 time 12:00**Classification:** – BS 8500-1 XS3, Ø 16 mm**Cement:** CEM II B-V (FLY ASH CEMENT) – 420 kg/m<sup>3</sup>**Admixture 1:** ASTM C494 TYPE F/G – 0.6 %**Admixture 2:** --**Admixture 3:** --

Aggregates	Grading:	0/16 (100%)	--	--	--
	Origin:	--	--	--	--

**Supplying:** Mobile plant Laboratory pan mixer **Delivery:** --**Fresh concr. test report:** --**Fresh concr. properties:** Bulk density: 2369 kg/m<sup>3</sup>; Water content: 197 kg/m<sup>3</sup>;  
Water/cement ratio: 0.43**Nominal size:** Cylinders: Ø = H = 50mm**Test carried out by:** IMM SA - Grancia**Duration of the analysis:** 19.09.2019 ÷ 20.09.2019**Technician:** Ing. Michele Paderi**Age at starting date:** 29 days

ID		1	2	3	4	
Diameter	[mm]	49.5	49.5	49.5	49.5	
Height	[mm]	50.4	49.6	50.8	51.0	
Bulk density	[kg/m <sup>3</sup> ]	2411	2404	2350	2400	
Mean voltage	[V]	20.25	20.25	20.25	20.25	
Mean temperature KOH	[°C]	21.4	21.4	21.4	21.5	
Mean temperature KOH+NaCl	[°C]	21.4	21.5	21.5	21.4	
Mean chloride penetration	[mm]	16	14	13	12	
Max chloride penetration	[mm]	18	17	14	14	
Chloride migration coefficient	[m <sup>2</sup> /s]	10.5 · 10 <sup>-12</sup>	9.0 · 10 <sup>-12</sup>	8.4 · 10 <sup>-12</sup>	7.8 · 10 <sup>-12</sup>	
Mean value	[m <sup>2</sup> /s]	<b>8.9 ± 1.14 · 10<sup>-12</sup></b>				
Threshold value for mean value	[m <sup>2</sup> /s]	-				

Remarks:

Grancia, 23.09.2019

Generla Manager: Dott. M. Di Tommaso

IMM field of activity: mechanical testing on concrete specimens

(Method statement: CI-12)

Results refer to tested samples only. The theoretical composition of the mixture is supplied by the Client and not tested by IMM.  
The only legally binding version is the original stamped and signed. Reproduction permitted upon approval.



Norma: SIA 262/1-B



## RESISTANCE TO CHLORIDE PENETRATION

**Client:** Penetron International

**Project:** Durability testing program - chlorides - CONTROL MIX

**Structure:** --

**Section:** --

**Casting:** Carried out by IMM; control on 21.08.2019 time 12:00

**Classification:** – BS 8500-1 XS3, Ø 16 mm

**Cement:** CEM II B-V (FLY ASH CEMENT) – 420 kg/m<sup>3</sup>

**Admixture 1:** ASTM C494 TYPE F/G – 0.6 %

**Admixture 2:** --

**Admixture 3:** --

Aggregates	Grading:	0/16 (100%)	--	--	--
	Origin:	--	--	--	--

**Supplying:** Mobile plant Laboratory pan mixer      **Delivery:** --

**Fresh concr. test report:** --

**Fresh concr. properties:** Bulk density: 2369 kg/m<sup>3</sup>; Water content: 197 kg/m<sup>3</sup>;  
 Water/cement ratio: 0.43

**Nominal size:** Cylinders: Ø = H = 50mm

**Test carried out by:** IMM SA - Grancia

**Duration of the analysis:** 17.10.2019 ÷ 18.10.2019

**Technician:** Ing. Michele Paderi

**Age at starting date:** 57 days

ID		5	6	7	8	9
Diameter	[mm]	49.5	49.7	49.7	49.5	49.5
Height	[mm]	49.6	50.0	50.1	50.1	50.3
Bulk densitz	[kg/m <sup>3</sup> ]	2412	2362	2362	2424	2378
Mean voltage	[V]	20.29	20.29	20.29	20.29	20.29
Mean temperature KOH	[°C]	21.2	21.2	21.3	21.3	21.3
Mean temperature KOH+NaCl	[°C]	21.3	21.3	21.3	21.4	21.4
Mean chloride penetration	[mm]	11	12	12	12	15
Max chloride penetration	[mm]	13	13	13	15	17
<b>Chloride migration coefficient</b>	<b>[m<sup>2</sup>/s]</b>	<b>7.0 · 10<sup>-12</sup></b>	<b>7.5 · 10<sup>-12</sup></b>	<b>8.0 · 10<sup>-12</sup></b>	<b>8.0 · 10<sup>-12</sup></b>	<b>10.1 · 10<sup>-12</sup></b>
<b>Mean value</b>	<b>[m<sup>2</sup>/s]</b>	<b>8.1 ± 1.18 · 10<sup>-12</sup></b>				
<b>Threshold value for mean value</b>	<b>[m<sup>2</sup>/s]</b>	-				

Remarks:

Grancia, 21.10.2019      General Manager: Dott. M. Di Tommaso

*M. Di Tommaso*



Standard: SIA 262/1-B



**RESISTANCE TO CHLORIDE PENETRATION**

**Client:** Penetron International

**Project:** Durability testing program - chlorides - CONTROL MIX

**Structure:** --

**Section:** --

**Casting:** Carried out by IMM; control on 21.08.2019 time 12:00

**Classification:** – BS 8500-1 XS3, Ø 16 mm

**Cement:** CEM II B-V (FLY ASH CEMENT) – 420 kg/m<sup>3</sup>

**Admixture 1:** ASTM C494 TYPE F/G – 0.6 %

**Admixture 2:** --

**Admixture 3:** --

**Aggregates** { **Grading:** 0/16 (100%) -- -- --  
**Origin:** -- -- -- --

**Supplying:** Mobile plant Laboratory pan mixer **Delivery:** --

**Fresh concr. test report:** --

**Fresh concr. properties:** Bulk density: 2369 kg/m<sup>3</sup>; Water content: 197 kg/m<sup>3</sup>;  
 Water/cement ratio: 0.43

**Nominal size:** Cylinders: Ø = H = 50mm

**Test carried out by:** IMM SA - Grancia

**Duration of the analysis:** 21.11.2019 ÷ 22.11.2019

**Technician:** Ing. Michele Paderi

**Age at starting date:** 92 days

ID		10	11	12	13	14
Diameter	[mm]	49.6	49.7	49.6	49.6	49.6
Height	[mm]	49.9	50.0	49.5	49.7	49.0
Bulk density	[kg/m <sup>3</sup> ]	2379	2381	2406	2399	2367
Mean voltage	[V]	20.25	20.25	20.25	20.25	20.25
Mean temperature KOH	[°C]	22.7	22.8	22.7	22.7	22.7
Mean temperature KOH+NaCl	[°C]	22.5	22.5	22.5	22.5	22.5
Mean chloride penetration	[mm]	9	7	7	7	9
Max chloride penetration	[mm]	10	8	8	8	10
<b>Chloride migration coefficient</b>	<b>[m<sup>2</sup>/s]</b>	<b>5.5 · 10<sup>-12</sup></b>	<b>4.4 · 10<sup>-12</sup></b>	<b>4.4 · 10<sup>-12</sup></b>	<b>4.2 · 10<sup>-12</sup></b>	<b>5.9 · 10<sup>-12</sup></b>
<b>Mean value</b>	<b>[m<sup>2</sup>/s]</b>	<b>4.9 ± 0.75 · 10<sup>-12</sup></b>				
<b>Threshold value for mean value</b>	<b>[m<sup>2</sup>/s]</b>	-				

Remarks:

Grancia, 25.11.2019 Generla Manager: Dott. M. Di Tommaso



Norma: SIA 262/1-B



## RESISTANCE TO CHLORIDE PENETRATION

**Client:** Penetron International

**Project:** Durability testing program - chlorides - CONTROL MIX

**Structure:** --

**Section:** --

**Casting:** Carried out by IMM; control on 21.08.2019 time 12:00

**Classification:** – BS 8500-1 XS3, Ø 16 mm

**Cement:** CEM II B-V (FLY ASH CEMENT) – 420 kg/m<sup>3</sup>

**Admixture 1:** ASTM C494 TYPE F/G – 0.6 %

**Admixture 2:** --

**Admixture 3:** --

Aggregates	Grading:	0/16 (100%)	--	--	--
	Origin:	--	--	--	--

**Supplying:** Mobile plant Laboratory pan mixer      **Delivery:** --

**Fresh concr. test report:** --

**Fresh concr. properties:** Bulk density: 2369 kg/m<sup>3</sup>; Water content: 197 kg/m<sup>3</sup>;  
 Water/cement ratio: 0.43

**Nominal size:** Cylinders: Ø = H = 50mm

**Test carried out by:** IMM SA - Grancia

**Duration of the analysis:** 19.12.2019 ÷ 20.12.2019

**Technician:** Ing. Michele Paderi

**Age at starting date:** 120 days

ID		15	16	17	18	19
Diameter	[mm]	49.2	49.2	49.2	49.2	49.2
Height	[mm]	52.0	53.0	53.0	53.0	53.0
Bulk densitz	[kg/m <sup>3</sup> ]	2432	2481	2444	2449	2445
Mean voltage	[V]	20.13	20.13	20.13	20.13	20.13
Mean temperature KOH	[°C]	22.9	22.8	22.8	22.8	22.9
Mean temperature KOH+NaCl	[°C]	22.7	22.9	22.9	22.9	23.0
Mean chloride penetration	[mm]	5	6	6	6	5
Max chloride penetration	[mm]	6	7	7	6	7
<b>Chloride migration coefficient</b>	<b>[m<sup>2</sup>/s]</b>	<b>3.3 · 10<sup>-12</sup></b>	<b>4.1 · 10<sup>-12</sup></b>	<b>4.1 · 10<sup>-12</sup></b>	<b>3.6 · 10<sup>-12</sup></b>	<b>3.5 · 10<sup>-12</sup></b>
<b>Mean value</b>	<b>[m<sup>2</sup>/s]</b>	<b>3.7 ± 0.40 · 10<sup>-12</sup></b>				
<b>Threshold value for mean value</b>	<b>[m<sup>2</sup>/s]</b>	-				

Remarks:

Grancia, 23.12.2019

General Manager: Dott. M. Di Tommaso



Standard: SIA 262/1-B



## RESISTANCE TO CHLORIDE PENETRATION

**Client:** Penetron International

**Project:** Durability testing program - chlorides - PENETRON MIX

**Structure:** --

**Section:** --

**Casting:** Carried out by IMM; control on 21.08.2019 time 12:30

**Classification:** – BS 8500-1 XS2, Ø 16 mm

**Cement:** CEM II B-V (FLY ASH CEMENT) – 380 kg/m<sup>3</sup>

**Admixture 1:** ASTM C494 TYPE F/G – 0.6 %

**Admixture 2:** Penetron – Admix® – 1 %

**Admixture 3:** --

Aggregates	Grading:	0/16 (100%)	--	--	--
	Origin:	--	--	--	--

**Supplying:** Mobile plant Laboratory pan mixer      **Delivery:** --

**Fresh concr. test report:** --

**Fresh concr. properties:** Bulk density: 2364 kg/m<sup>3</sup>; Water content: 199 kg/m<sup>3</sup>;  
 Water/cement ratio: 0.48

**Nominal size:** Cylinders: Ø = H = 50mm

**Test carried out by:** IMM SA - Grancia

**Duration of the analysis:** 19.09.2019 ÷ 20.09.2019

**Technician:** Ing. Michele Paderi

**Age at starting date:** 29 days

ID		1	2	3	4	5
Diameter	[mm]	49.5	49.5	49.5	49.5	49.5
Height	[mm]	50.3	50.8	51.0	51.0	50.7
Bulk densitz	[kg/m <sup>3</sup> ]	2395	2422	2414	2439	2404
Mean voltage	[V]	20.25	20.25	20.25	20.25	20.25
Mean temperature KOH	[°C]	21.5	21.4	21.5	21.4	21.5
Mean temperature KOH+NaCl	[°C]	21.5	21.5	21.5	21.5	21.5
Mean chloride penetration	[mm]	14	14	13	17	14
Max chloride penetration	[mm]	17	17	17	19	16
<b>Chloride migration coefficient</b>	<b>[m<sup>2</sup>/s]</b>	<b>9.2 · 10<sup>-12</sup></b>	<b>9.2 · 10<sup>-12</sup></b>	<b>8.8 · 10<sup>-12</sup></b>	<b>11.2 · 10<sup>-12</sup></b>	<b>9.0 · 10<sup>-12</sup></b>
<b>Mean value</b>	<b>[m<sup>2</sup>/s]</b>	<b>9.5 ± 0.98 · 10<sup>-12</sup></b>				
<b>Threshold value for mean value</b>	<b>[m<sup>2</sup>/s]</b>	-				

Remarks:

Grancia, 23.09.2019

Generla Manager: Dott. M. Di Tommaso

**IMM**

Istituto Meccanica dei Materiali SA

Via al Molino 55 - 6916 Grancia - Switzerland  
T +41 91 994 83 41 E-mail imm@imm.ch  
F +41 91 994 85 30 Web www.imm.ch

Test report:

**CLO11374G**

Norma: SIA 262/1-B

**RESISTANCE TO CHLORIDE PENETRATION****Client:** Penetron International**Project:** Durability testing program - chlorides - PENETRON MIX**Structure:** --**Section:** --**Casting:** Carried out by IMM; control on 21.08.2019 time 12:30**Classification:** – BS 8500-1 XS2, Ø 16 mm**Cement:** CEM II B-V (FLY ASH CEMENT) – 380 kg/m<sup>3</sup>**Admixture 1:** ASTM C494 TYPE F/G – 0.6 %**Admixture 2:** Penetron – Admix® – 1 %**Admixture 3:** --

Aggregates	Grading:	0/16 (100%)	--	--	--
	Origin:	--	--	--	--

**Supplying:** Mobile plant Laboratory pan mixer **Delivery:** --**Fresh concr. test report:** --**Fresh concr. properties:** Bulk density: 2364 kg/m<sup>3</sup>; Water content: 199 kg/m<sup>3</sup>;  
Water/cement ratio: 0.48**Nominal size:** Cylinders: Ø = H = 50mm**Test carried out by:** IMM SA - Grancia**Duration of the analysis:** 16.10.2019 ÷ 17.10.2019**Technician:** Tec. M. Somazzi**Age at starting date:** 56 days

ID		6	7	8	9	10
Diameter	[mm]	49.7	49.7	49.7	49.7	49.7
Height	[mm]	49.2	49.5	49.4	49.5	49.5
Bulk densitz	[kg/m <sup>3</sup> ]	2394	2399	2373	2388	2389
Mean voltage	[V]	20.26	20.26	20.26	20.26	20.26
Mean temperature KOH	[°C]	21.1	21.1	21.2	21.2	21.1
Mean temperature KOH+NaCl	[°C]	21.1	21.1	21.2	21.2	21.2
Mean chloride penetration	[mm]	11	7	8	7	8
Max chloride penetration	[mm]	12	8	9	7	8
<b>Chloride migration coefficient</b>	<b>[m<sup>2</sup>/s]</b>	<b>6.6 · 10<sup>-12</sup></b>	<b>4.6 · 10<sup>-12</sup></b>	<b>5.1 · 10<sup>-12</sup></b>	<b>4.3 · 10<sup>-12</sup></b>	<b>4.8 · 10<sup>-12</sup></b>
<b>Mean value</b>	<b>[m<sup>2</sup>/s]</b>	<b>5.1 ± 0.90 · 10<sup>-12</sup></b>				
<b>Threshold value for mean value</b>	<b>[m<sup>2</sup>/s]</b>	-				

Remarks:

Grancia, 18.10.2019

General Manager: Dott. M. Di Tommaso

IMM field of activity: mechanical testing on concrete specimens

(Method statement: Cl-12)

Results refer to tested samples only. The theoretical composition of the mixture is supplied by the Client and not tested by IMM.  
The only legally binding version is the original stamped and signed. Reproduction permitted upon approval.



Standard: SIA 262/1-B



## RESISTANCE TO CHLORIDE PENETRATION

**Client:** Penetron International

**Project:** Durability testing program - chlorides - PENETRON MIX

**Structure:** --

**Section:** --

**Casting:** Carried out by IMM; control on 21.08.2019 time 12:30

**Classification:** – BS 8500-1 XS2, Ø 16 mm

**Cement:** CEM II B-V (FLY ASH CEMENT) – 380 kg/m<sup>3</sup>

**Admixture 1:** ASTM C494 TYPE F/G – 0.6 %

**Admixture 2:** Penetron – Admix ® – 1 %

**Admixture 3:** --

Aggregates	Grading:	0/16 (100%)	--	--	--
	Origin:	--	--	--	--

**Supplying:** Mobile plant Laboratory pan mixer      **Delivery:** --

**Fresh concr. test report:** --

**Fresh concr. properties:** Bulk density: 2363 kg/m<sup>3</sup>; Water content: 198 kg/m<sup>3</sup>;  
 Water/cement ratio: 0.48

**Nominal size:** Cylinders: Ø = H = 50mm

**Test carried out by:** IMM SA - Grancia

**Duration of the analysis:** 20.11.2019 ÷ 21.11.2019

**Technician:** Ing. Michele Paderi

**Age at starting date:** 91 days

ID		11	12	13	14	15
Diameter	[mm]	49.5	49.5	49.5	49.5	49.5
Height	[mm]	48.7	48.6	48.6	48.5	48.7
Bulk densitz	[kg/m <sup>3</sup> ]	2448	2411	2431	2432	2423
Mean voltage	[V]	20.23	20.23	20.23	20.23	20.23
Mean temperature KOH	[°C]	22.7	22.6	22.6	22.6	22.6
Mean temperature KOH+NaCl	[°C]	22.9	22.9	23.0	22.9	22.9
Mean chloride penetration	[mm]	8	10	5	7	7
Max chloride penetration	[mm]	10	11	6	8	8
<b>Chloride migration coefficient</b>	<b>[m<sup>2</sup>/s]</b>	<b>5.2 · 10<sup>-12</sup></b>	<b>6.0 · 10<sup>-12</sup></b>	<b>2.8 · 10<sup>-12</sup></b>	<b>4.0 · 10<sup>-12</sup></b>	<b>4.5 · 10<sup>-12</sup></b>
<b>Mean value</b>	<b>[m<sup>2</sup>/s]</b>	<b>4.5 ± 1.18 · 10<sup>-12</sup></b>				
<b>Threshold value for mean value</b>	<b>[m<sup>2</sup>/s]</b>	-				

Remarks:

Grancia, 25.11.2019

Generla Manager: Dott. M. Di Tommaso

**IMM**

Istituto Meccanica dei Materiali SA

Via al Molino 55 - 6916 Grancia - Switzerland  
T +41 91 994 83 41 E-mail imm@imm.ch  
F +41 91 994 85 30 Web www.imm.ch

Test report:

**CLO11374G**

Norma: SIA 262/1-B

**RESISTANCE TO CHLORIDE PENETRATION****Client:** Penetron International**Project:** Durability testing program - chlorides - PENETRON MIX**Structure:** --**Section:** --**Casting:** Carried out by IMM; control on 21.08.2019 time 12:30**Classification:** – BS 8500-1 XS2, Ø 16 mm**Cement:** CEM II B-V (FLY ASH CEMENT) – 380 kg/m<sup>3</sup>**Admixture 1:** ASTM C494 TYPE F/G – 0.6 %**Admixture 2:** Penetron – Admix® – 1 %**Admixture 3:** --

Aggregates	Grading:	0/16 (100%)	--	--	--
	Origin:	--	--	--	--

**Supplying:** Mobile plant Laboratory pan mixer **Delivery:** --**Fresh concr. test report:** --**Fresh concr. properties:** Bulk density: 2363 kg/m<sup>3</sup>; Water content: 198 kg/m<sup>3</sup>;

Water/cement ratio: 0.48

**Nominal size:** Cylinders: Ø = H = 50mm**Test carried out by:** IMM SA - Grancia**Duration of the analysis:** 19.12.2019 ÷ 20.12.2019**Technician:** Tec. M. Somazzi**Age at starting date:** 120 days

ID		16	17	18	19	20
Diameter	[mm]	49.3	49.3	49.3	49.3	49.3
Height	[mm]	52.0	50.7	51.3	51.5	50.0
Bulk densitz	[kg/m <sup>3</sup> ]	2427	2443	2398	2388	2395
Mean voltage	[V]	20.13	20.13	20.13	20.13	20.13
Mean temperature KOH	[°C]	22.7	22.8	22.8	22.9	22.9
Mean temperature KOH+NaCl	[°C]	22.9	22.9	22.9	22.9	22.8
Mean chloride penetration	[mm]	5	6	4	4	5
Max chloride penetration	[mm]	6	7	5	5	6
<b>Chloride migration coefficient</b>	<b>[m<sup>2</sup>/s]</b>	<b>3.3 · 10<sup>-12</sup></b>	<b>3.9 · 10<sup>-12</sup></b>	<b>2.6 · 10<sup>-12</sup></b>	<b>2.7 · 10<sup>-12</sup></b>	<b>3.0 · 10<sup>-12</sup></b>
<b>Mean value</b>	<b>[m<sup>2</sup>/s]</b>	<b>3.1 ± 0.51 · 10<sup>-12</sup></b>				
<b>Threshold value for mean value</b>	<b>[m<sup>2</sup>/s]</b>	-				

Remarks:

Grancia, 23.12.2019

General Manager: Dott. M. Di Tommaso

IMM field of activity: mechanical testing on concrete specimens

(Method statement: Cl-12)

Results refer to tested samples only. The theoretical composition of the mixture is supplied by the Client and not tested by IMM.  
The only legally binding version is the original stamped and signed. Reproduction permitted upon approval.