



European Technical Assessment

ETA 17/0908
of 18.02.2020



General part

Technical Assessment Body issuing the ETA: ITeC	
ITeC has been designated according to Article 29 of Regulation (EU) No 305/2011 and is member of EOTA (European Organisation for Technical Assessment)	
Trade name of the construction product	Pozzolanica Solena
Product family to which the construction product belongs	26 – Products related to concrete, mortar and grout.
Manufacturer	SOLENA s.r.l. Via C. Cattaneo 62 IT-23900 Lecco Italy
Manufacturing plant(s)	Via Strada Statale dei Giovi 80 Paderno Dugnano IT-20037 Milano Italy
This European Technical Assessment contains	15 pages
This European Technical Assessment is issued in accordance with Regulation (EU) 305/2011, on the basis of	European Assessment Document 260009-00-0301 <i>Processed bottom ash from municipal solid waste incinerators as type II addition for production of concrete, mortar and grout.</i>
This version replaces	ETA 17/0908 of 24.05.2018

General comments

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Specific parts of the European Technical Assessment

1 Technical description of the product

Pozzolanica Solena is a type II addition obtained by physical and chemical treatment of municipal solid waste incinerators bottom ashes (MIBA) deriving from municipal solid waste incinerators (waste from households as well as commercial, industrial and institutional waste which, because of its nature and composition, is similar to waste from households, excluding hazardous waste).

The treatment process is characterized by wet micronization of the mineral particles, by the high level reached of separation of metal scraps initially present in MIBA and, particularly, by the fact that the final product is metallic aluminium free and therefore does no longer induce hydrogen formation¹.

The final product (which, after wet micronization in form of slurry, undergoes a partial dehydration phase) is a humid aggregate with sand appearance and a grain size about 0 mm to 6 mm, constituted of elemental fine particles aggregated in clusters. The water present in the product should be considered as hydration water in concrete design.

The product is normally used in combination with a plasticizer and/or superplasticizer and, in particular conditions, depending on the other components of concrete, the mix design, etc., it may require an addition of a defoamer² in order to avoid the entrapment of excess of air. The granulate form may require an additional mixing time to disperse the particles.

The product is registered under REACH and its EC number is 939-997-0.

Concerning product packaging, transport, and storage, it is the responsibility of the manufacturer to undertake the appropriate measures and to advise his clients on the transport and storage, of the product as he considers necessary.

It is assumed that the product will be installed according to the manufacturer's instructions or (in absence of such instructions) according to the usual practice of the building professionals.

2 Specification of the intended use(s) in accordance with the applicable EAD

Pozzolanica Solena is intended for use as type II addition for concrete, including cast-in-situ or prefabricated structural concrete conforming to European standard EN-206. It may also be used in mortars and grouts.

Pozzolanica Solena is intended to be used in combination with Portland cement (CEM I) and Portland-composite cements (CEM II/A) with the percentages indicated in annex A. Assessed exposure classes are indicated in annex B.

3 Performance of the product and reference to the methods used for its assessment

Performances of the Pozzolanica Solena type II addition, related to the basic requirements for construction works (hereinafter BWR), were determined according to EAD 260009-00-0301 *Processed bottom ash from municipal solid waste incinerators as type II addition for production of concrete, mortar and grout*. Essential characteristics of Pozzolanica Solena are included in table 3.1.

¹ Hydrogen formation may cause problems of expansion on fresh concrete, this is a well-known phenomenon of MIBA.

² The product is normally added with a certain quantity of defoamer at the production site. However, in some concretes, depending mostly on superplasticizer and also on mix design and the other constituents (cement, aggregates, etc.), it is necessary to add additional quantities of defoamer.

Basic Works Requirement	Essential characteristic	Performance			
BWR 1 Mechanical resistance and stability	Composition ⁽¹⁾	SiO ₂ + Al ₂ O ₃ + Fe ₂ O ₃	63,59 %		
		Total sulphates (SO ₃) (≤ 3 %)	0,47 %		
		Total chlorides (Cl ⁻)	0,16 %		
		Water soluble chlorides (Cl ⁻)	0,14 %		
		Total phosphates (P ₂ O ₅) (≤ 5 %)	1,25 %		
	Activity index ⁽²⁾	At 28 days (≥ 75 %)	82,4 %		
		At 90 days (≥ 85 %)	87,1 %		
	Fineness	By wet sieving (≤ 12,0 % by mass)	0,2 %		
		By laser diffraction	D(v;0,5) = 14,40µm		
	Soundness ⁽³⁾	Reference mortar	- 1,08%		
		Assessed mortar	- 1,22%		
	Moisture content ⁽¹⁾		12,8%		
	Loss on ignition ⁽¹⁾		5,2%		
	Particle density		NPD ⁽⁴⁾		
	Initial setting time		Initial setting time	Final setting time	Limit of setting time
		Reference mortar	2 h 05 min	3 h 30 min	--
		Assessed mortar	2 h 25 min	3 h 35 min	≤ 4 h 10 min
Compressive strength		See annex A			
Depth of penetration of water under pressure		See annex B1			
Relative carbonation resistance		See annex B2			
Chloride diffusion resistance		See annex B3			
Sulphate resistance		See annex B4			

Notes:

- (1) Percentage by mass.
- (2) Percentage between the compressive resistance of the assessed mortar and the reference mortar.
- (3) Percentage of change in height of the assessed mortar and the reference mortar related to their initial values.
- (4) NPD: No Performance Determined.

Table 3.1: Performance of Pozzolanica Solena.

4 Assessment and verification of constancy of performance (AVCP) system applied, with reference to its legal base

According to the Decision 1999/469/EC amended by Decision 2001/596/EC, as amended of the European Commission³, the system of AVCP (see EC delegated regulation (EU) No 568/2014 amending Annex V to Regulation (EU) 305/2011) given in the following table applies:

Product	Intended use	System
Pozzolanica Solena	Addition type II for concrete, mortar and grout	1+

Table 4.1: Applicable AVCP System.

5 Technical details necessary for the implementation of the AVCP system, as foreseen in the applicable EAD

All the necessary technical details for the implementation of the AVCP system are laid down in the *Control Plan* deposited with the ITeC⁴, with which the factory production control shall be in accordance.

Any change in the manufacturing procedure which may affect the properties of the product shall be notified and the necessary type-testing revised according to the *Control Plan*.

Issued in Barcelona on 18 February 2020

by the Catalonia Institute of Construction Technology.



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³ Official Journal of the European Union (OJEU) L184/27 of 25/06/1999.
Official Journal of the European Union (OJEU) L209/33 of 02/08/2011.

⁴ The *Control Plan* is a confidential part of the ETA and is only handed over to the notified certification body involved in the assessment and verification of constancy of performance.

ANNEX A: COMPRESSION STRENGTH AND K VALUE

Cement	Age (days)	Water / cement (ω_a) ⁽¹⁾	k function of ω_r	Minimum k value
60 % CEM I 52.5R + 40 % Pozzolanica Solena	7	0,40		-- ⁽²⁾
		0,50	$\frac{-1,326}{\omega_r} + 2,707$	0,05
		0,60		0,50
	28	0,40		0,16
		0,50	$\frac{-0,468}{\omega_r} + 1,324$	0,39
		0,60		0,54
	90	0,40		-- ⁽²⁾
		0,50	$\frac{-0,223}{\omega_r} + 1,158$	0,31
		0,60		0,59
67 % CEM I 52.5R + 33 % Pozzolanica Solena	7	0,40		0,35
		0,50	$\frac{-0,432}{\omega_r} + 1,426$	0,56
		0,60		0,71
	28	0,40		0,65
		0,50	$\frac{-0,050}{\omega_r} + 0,770$	0,67
		0,60		0,69
	90	0,40		0,25
		0,50	$\frac{-0,223}{\omega_r} + 1,158$	0,53
		0,60		0,71
80 % CEM I 52.5R + 20 % Pozzolanica Solena	7	0,40		0,36
		0,50	$\frac{-0,576}{\omega_r} + 1,798$	0,65
		0,60		0,84
	28	0,40		0,61
		0,50	$\frac{-0,234}{\omega_r} + 1,191$	0,72
		0,60		0,80
	90	0,40		0,42
		0,50	$\frac{-0,318}{\omega_r} + 1,638$	0,63
		0,60		0,77
70 % CEM II/A-LL 42.5R + 30 % Pozzolanica Solena	7	0,40		-- ⁽²⁾
		0,50	$\frac{-1,004}{\omega_r} + 2,323$	0,32
		0,60		0,65
	28	0,40		0,40
		0,50	$\frac{-0,325}{\omega_r} + 1,210$	0,56
		0,60		0,67
	90	0,40		0,44
		0,50	$\frac{-0,200}{\omega_r} + 1,127$	0,51
		0,60		0,55
75 % CEM I 52.5R + 25 % Pozzolanica Solena	7	0,40		-- ⁽²⁾
		0,50	$\frac{-0,817}{\omega_r} + 2,029$	0,40
		0,60		0,67
	28	0,40		0,51
		0,50	$\frac{-0,235}{\omega_r} + 1,138$	0,63
		0,60		0,72

Cement	Age (days)	Water / cement (ω_a) ⁽¹⁾	k function of ω_r	Minimum k value
85 % CEM II/A-LL 42.5R + 15 % Pozzolanica Solena	90	0,40	$\frac{-0,223}{\omega_r} + 1,158$	0,54
		0,50		0,56
		0,60		0,57
	7	0,40	$\frac{-1,062}{\omega_r} + 2,558$	-- ⁽²⁾
		0,50		0,43
		0,60		0,79
	28	0,40	$\frac{0,287}{\omega_r} + 1,256$	0,54
		0,50		0,68
		0,60		0,78
90	0,40	$\frac{0,145}{\omega_r} + 0,744$	0,40	
	0,50		0,53	
	0,60		0,62	

Notes:

- ⁽¹⁾ The water / cement ratio of the assessed mortar (ω_a) is the same water / cement ratio as the reference mortar (ω_r).
- ⁽²⁾ Negative k values are not declared since they have no physical meaning.

Table A1: k values.

ANNEX B: EQUIVALENT DURABILITY

Test scheme for the assessment of equivalent durability:

Cements involved in the assessment		Exposure class
Reference	Assessment	
CEM II/A-LL 42.5R	75 % CEM II/A-LL 42.5R	XC4 + XD3 + XS3
CEM IV/A (V) 42.5R ⁽¹⁾	+ 25 % Pozzolanica Solena	XC4 + XD3 + XS3 + XA3

Notes:

- ⁽¹⁾ The reference and the assessment cement are not the same when assessing the exposure class XA3. CEM IV/A (V) 42.5R is needed to assess the exposure classes XC4 + XD3 + XS3 + XA3. It has not technical sense to use CEM IV/A 42.5R + 40% Pozzolanica Solena as assessment cement, because of the high percentage of Pozzolanica Solena in this cement, and also because the ETA holder does not want to add Pozzolanica Solena to the CEM IV.

Table B0: Test scheme for the assessment of equivalent durability.

ANNEX B1: DEPTH OF PENETRATION OF WATER UNDER PRESSURE

Concrete	Water / cement ratio	Depth of penetration (max./mean) of water under pressure (EN 12390-8) [mm]			
		Specimen			Mean value
		1	2	3	
100 % CEM IV 42.5R	$\omega_1 = 0,43$	12/10	12/9	13/10	12/10
	$\omega_2 = 0,45$	13/10	12/10	13/11	13/10
	$\omega_3 = 0,47$	14/11	14/11	13/10	14/11
100 % CEM II/A-LL 42.5R	$\omega_1 = 0,43$	15/12	17/12	16/11	16/12
	$\omega_2 = 0,45$	18/15	20/15	18/14	19/15
	$\omega_3 = 0,47$	30/22	31/22	30/23	30/22
75 % CEM II/A-LL 42.5R + 25 % Pozzolanica Solena	$\omega_1 = 0,376$	18/8	19/9	18/7	18/8
	$\omega_2 = 0,394$	21/10	19/11	20/10	20/10
	$\omega_3 = 0,411$	22/11	23/12	22/12	22/12

Table B1: Depth of penetration of water under pressure.

ANNEX B2: RELATIVE CARBONATION RESISTANCE

The relative carbonation resistance after 90, 182 and 273 days are displayed in tables B2.1, B2.2 and B2.3, respectively. The evolution of the carbonation depth over time is displayed in table B2.4.

Concrete	Water / cement ratio	Carbonation depth (d_k) (CEN/TS 12390-10) [mm]						Mean values
		Specimen	After 90 days				Mean values	
			A	B	C	D		
100 % CEM IV 42.5R	$\omega_1 = 0,43$	211 A	0,0	0,6	0,0	0,4	0,2	0,3
		211 B	0,0	0,0	1,6	0,0	0,4	
	$\omega_2 = 0,45$	212 A	1,4	0,9	1,1	1,1	1,1	0,7
		212 B	0,0	0,7	0,0	0,3	0,2	
	$\omega_3 = 0,47$	213 A	0,0	1,3	1,5	0,0	0,7	0,7
		213 B	0,0	0,0	1,5	1,0	0,6	
100 % CEM II/A- LL 42.5R	$\omega_1 = 0,43$	208 A	0,0	0,0	0,0	0,7	0,2	0,8
		208 B	1,9	0,5	2,9	0,0	1,3	
	$\omega_2 = 0,45$	209 A	0,0	1,9	1,1	0,0	0,8	0,6
		209 B	1,0	0,0	0,0	1,1	0,5	
	$\omega_3 = 0,47$	210 A	0,0	2,8	3,0	0,0	1,5	1,2
		210 B	0,2	0,0	1,9	1,8	1,0	
75 % CEM II/A- LL 42.5R + 25 % Pozzolonica Solena	$\omega_1 = 0,376$	214 A	0,0	0,0	1,7	0,0	0,4	0,5
		214 B	0,0	0,0	1,9	0,0	0,5	
	$\omega_2 = 0,394$	215 A	0,0	2,3	0,8	0,9	1,0	0,9
		215 B	0,0	0,4	0,4	2,3	0,8	
	$\omega_3 = 0,411$	216 A	0,0	0,0	1,7	0,0	0,4	0,7
		216 B	0,0	2,0	1,8	0,0	0,9	

Table B2.1: Carbonation depth at 90 days.

Concrete	Water / cement ratio	Carbonation depth (d_k) (CEN/TS 12390-10) [mm]						Mean values
		Specimen	After 182 days				Mean values	
			A	B	C	D		
100 % CEM IV 42.5R	$\omega_1 = 0,43$	211 A	2,0	2,8	2,9	3,0	2,6	2,3
		211 B	2,5	0,0	3,0	3,0	2,1	
	$\omega_2 = 0,45$	212 A	3,0	2,8	3,6	3,2	3,2	3,3
		212 B	3,8	3,5	2,9	3,5	3,4	
	$\omega_3 = 0,47$	213 A	3,5	3,2	2,8	4,3	3,4	3,5
		213 B	3,7	3,9	2,4	3,9	3,5	
100 % CEM II/A- LL 42.5R	$\omega_1 = 0,43$	208 A	2,9	2,0	2,9	3,6	2,9	2,9
		208 B	2,2	3,4	2,6	3,4	2,9	
	$\omega_2 = 0,45$	209 A	3,1	2,5	3,7	3,0	3,1	3,0
		209 B	2,3	4,1	3,2	2,2	3,0	

Concrete	Water / cement ratio	Carbonation depth (d_k) (CENTS 12390-10) [mm]						
		After 182 days						
		Specimen	Face of specimen				Mean values	
A	B		C	D				
75 % CEM II/A- LL 42.5R + 25 % Pozzolanica Solena	$\omega_3 = 0,47$	210 A	4,9	3,6	4,6	4,5	4,4	4,1
		210 B	3,5	4,3	3,6	4,1	3,9	
	$\omega_1 = 0,376$	214 A	2,9	1,9	3,8	3,2	3,0	2,6
		214 B	2,4	2,8	2,1	1,4	2,2	
	$\omega_2 = 0,394$	215 A	1,6	3,0	2,7	3,2	2,6	2,8
		215 B	2,7	3,7	2,4	2,9	2,9	
	$\omega_3 = 0,411$	216 A	4,2	3,4	1,8	3,8	3,3	3,0
		216 B	2,9	2,6	2,7	2,7	2,7	

Table B2.2. Carbonation depth at 182 days.

Concrete	Water / cement ratio	Carbonation depth (d_k) (CENTS 12390-10) [mm]						
		After 273 days						
		Specimen	Face of specimen				Mean values	
A	B		C	D				
100 % CEM IV 42.5R	$\omega_1 = 0,43$	211 A	-- (1)	-- (1)	-- (1)	-- (1)	-- (1)	2,9
		211 B	2,5	3,0	3,1	3,1	2,9	
	$\omega_2 = 0,45$	212 A	3,3	3,3	2,4	-- (1)	3,0	3,5
		212 B	3,1	5,5	3,8	3,5	3,9	
	$\omega_3 = 0,47$	213 A	4,0	-- (1)	-- (1)	3,0	3,5	3,5
		213 B	-- (1)	-- (1)	-- (1)	3,5	3,5	
100 % CEM II/A- LL 42.5R	$\omega_1 = 0,43$	208 A	1,9	4,6	3,1	3,5	3,3	3,4
		208 B	3,7	4,6	3,1	2,3	3,4	
	$\omega_2 = 0,45$	209 A	3,5	3,3	-- (1)	4,0	3,6	3,4
		209 B	2,8	3,1	3,8	-- (1)	3,2	
	$\omega_3 = 0,47$	210 A	3,7	4,0	3,7	5,6	4,0	4,1
		210 B	4,7	4,2	3,6	3,9	4,1	
75 % CEM II/A- LL 42.5R + 25 % Pozzolanica Solena	$\omega_1 = 0,376$	214 A	4,0	-- (1)	-- (1)	1,8	2,9	2,8
		214 B	2,0	-- (1)	-- (1)	3,5	2,7	
	$\omega_2 = 0,394$	215 A	3,4	-- (1)	4,1	3,5	3,7	3,8
		215 B	4,3	4,2	3,6	3,8	4,0	
	$\omega_3 = 0,411$	216 A	4,1	3,3	4,2	4,4	4,0	4,2
		216 B	4,7	5,0	4,3	3,8	4,5	

Table B2.3. Carbonation depth at 273 days.

Concrete	Water / cement ratio	Carbonation depth (mean value) (d_{km}) [mm] according to the exposure time in days		
		90	182	273
100 % CEM IV 42.5R	0,43	0,3	2,3	2,9
100 % CEM II/A-LL 42.5R	0,43	0,8	2,9	3,4
75 % CEM II/A-LL 42.5R + 25 % Pozzolanica Solena	0,376	0,5	2,9	2,8
100 % CEM IV 42.5R	0,45	0,7	3,3	3,5
100 % CEM II/A-LL 42.5R	0,45	0,6	3,0	3,4
75 % CEM II/A-LL 42.5R + 25 % Pozzolanica Solena	0,394	0,9	2,8	3,8
100 % CEM IV 42.5R	0,47	0,7	3,5	3,5
100 % CEM II/A-LL 42.5R	0,47	1,2	4,1	4,1
75 % CEM II/A-LL 42.5R + 25 % Pozzolanica Solena	0,411	0,7	3,0	4,2

Table B2.4: Evolution of the carbonation depth over time.

ANNEX B3: CHLORIDE DIFFUSION RESISTANCE

Concrete	Water / cement ratio	Chloride penetration with left-right edge colorimetric measurement (EN 12390-11) [mm]						
		Specimen	Measurement point					Mean value
			1	2	3	4	5	
100 % CEM II/A- LL 42.5R	$\omega_1 = 0,43$	208A'	5	7	9	14	6	8
	$\omega_2 = 0,45$	209A'	15	13	11	12	11	12
	$\omega_3 = 0,47$	210A'	17	15	10	14	13	14
100 % CEM IV 42.5R	$\omega_1 = 0,43$	211A'	7	6	10	6	9	7
	$\omega_2 = 0,45$	212A'	16	5	7	11	18	11
	$\omega_3 = 0,47$	213A'	6	7	-- ⁽¹⁾	9	6	7
75 % CEM II/A- LL 42.5R + 25 % Pozzolonica Solena	$\omega_1 = 0,376$	214A'	8	11	15	11	10	11
	$\omega_2 = 0,394$	215A'	11	10	9	8	9	9
	$\omega_3 = 0,411$	216A'	7	9	7	10	15	10

Note:

⁽¹⁾ The presence of a big aggregate in this point made the measurement not possible.

Table B3.1: Chloride penetration.

Specimen	Reference level in potable water	Content of chloride [%] in the concrete				
		At the depth [mm] of:				
		0 – 4	4 – 8	8 – 12	12 – 16	16 – 20
208A'	0,035	0,488	0,290	0,188	0,098	0,063
209A'	0,029	0,583	0,335	0,239	0,126	0,078
210A'	0,016	0,549	0,383	0,227	0,153	0,094
211A'	0,016	0,541	0,382	0,179	0,089	0,036
212A'	0,013	0,364	0,298	0,151	0,073	0,074
213A'	0,013	0,475	0,355	0,246	0,065	0,037
214A'	0,023	0,453	0,319	0,151	0,065	0,047
215A'	0,014	0,270	0,250	0,117	0,047	0,038
216A'	0,033	0,312	0,324	0,214	0,100	0,067

Table B3.2: Quantitative profile of chloride penetration.

ANNEX B4: SULPHATE RESISTANCE

4,4 % Na₂SO₄ solution at 20 °C (sulphate storage at 20 °C)							
Assessed characteristics (mean value of 3 specimens) for CEM IV/A (V) 42.5R ($\omega_2 = 0,45$)							
Age of specimens [days]	Dimensions (height, width and length) [mm]			Expansion of the length (ΔL) [mm/m]	Weight [g]	Density (D) (EN 12390-7) [kg/m ³]	Elastic modulus $E_d = D \cdot V^2 \cdot 0,83$ (EN 12504-1) [N/mm ²]
0	14,21	39,90	159,99	--	212,56	2.343	38.208
14	14,20	39,87	159,97	-0,125	212,43	2.346	38.656
28	14,18	39,82	159,93	-0,375	212,37	2.353	39.567
56	14,17	39,85	159,93	-0,375	213,25	2.361	41.390
90	14,21	39,92	159,98	-0,063	214,91	2.368	43.405
180	14,25	39,75	159,89	-0,625	214,88	2.372	45.227
Assessed characteristics (mean value of 3 specimens) for 75 % CEM II/A-LL 42.5R + 25% Pozzolanica Solena ($\omega_2 = 0,394$)							
Age of specimens [days]	Dimensions (height, width and length) [mm]			Expansion of the length (ΔL) [mm/m]	Weight [g]	Density (D) (EN 12390-7) [kg/m ³]	Elastic modulus $E_d = D \cdot V^2 \cdot 0,83$ (EN 12504-1) [N/mm ²]
0	13,63	39,91	159,79	--	210,51	2.425	38.364
14	13,64	39,84	159,73	-0,375	210,66	2.432	39.373
28	13,65	39,83	159,70	-0,563	211,17	2.437	39.967
56	13,72	39,59	159,67	-0,751	211,49	2.448	43.114
90	13,72	39,58	159,66	-0,814	211,70	2.451	46.045
180	13,70	39,72	159,58	-1,314	213,20	2.464	47.833

Table B4.1: Sulphate resistance assessment (sulphate storage at 20 °C).

4,4 % Na₂SO₄ solution at 5 °C (sulphate storage at 5°C).							
Assessed characteristics (mean value of 3 specimens) for CEM IV/A (V) 42.5R ($\omega_2 = 0,45$)							
Age of specimens [days]	Dimensions (height, width and length) [mm]			Expansion of the length (ΔL) [mm/m]	Weight [g]	Density (D) (EN 12390-7) [kg/m ³]	Elastic modulus $E_d = D \cdot V^2 \cdot 0,83$ (EN 12504-1) [N/mm ²]
0	12,93	39,91	159,87	--	202,07	2.381	35.192
14	13,56	39,91	159,88	0,063	202,30	2.372	36.254
28	13,40	39,92	159,84	-0,188	202,59	2.370	37.797
56	13,40	39,89	159,86	-0,063	202,87	2.373	38.343
90	13,35	39,99	159,82	-0,313	202,98	2.379	39.008
180	13,39	39,92	159,74	-0,813	204,06	2.389	43.695

Assessed characteristics (mean value of 3 specimens) for 75 % CEM II/A-LL 42.5R + 25% Pozzolanica Solena ($\omega_2 = 0,394$)							
Age of specimens [days]	Dimensions (height, width and length) [mm]			Expansion of the length (ΔL) [mm/m]	Weight [g]	Density (D) (EN 12390-7) [kg/m ³]	Elastic modulus $E_d = D \cdot V^2 \cdot 0,83$ (EN 12504-1) [N/mm ²]
0	13,99	39,91	159,87	--	214,86	2.409	36.556
14	13,98	39,91	159,82	-0,313	214,93	2.412	36.947
28	13,99	39,91	159,77	-0,626	214,85	2.412	37.358
56	14,05	40,00	159,73	-0,876	215,77	2.407	40.255
90	14,10	39,90	159,73	-0,876	216,11	2.408	42.437
180	14,09	39,88	159,75	-0,751	216,26	2.411	42.429

Table B4.2: Sulphate resistance assessment (sulphate storage at 5°C).

Saturated Ca(OH) ₂ solution at 20 °C (reference storage at 20 °C).							
Assessed characteristics (mean value of 3 specimens) for CEM IV/A (V) 42.5R ($\omega_2 = 0,45$)							
Age of specimens [days]	Dimensions (height, width and length) [mm]			Expansion of the length (ΔL) [mm/m]	Weight [g]	Density (D) (EN 12390-7) [kg/m ³]	Elastic modulus $E_d = D \cdot V^2 \cdot 0,83$ (EN 12504-1) [N/mm ²]
0	12,57	40,00	160,01	--	190,99	2.373	36.138
14	12,64	40,04	160,01	0,000	191,26	2.360	36.914
28	12,66	40,05	159,99	-0,125	191,64	2.361	39.464
56	12,67	40,09	159,97	-0,250	191,95	2.359	39.464
90	12,65	40,09	159,95	-0,375	192,24	2.369	41.622
180	12,55	40,06	159,85	-1,000	193,2	2.405	44.296

Assessed characteristics (mean value of 3 specimens) for 75 % CEM II/A-LL 42.5R + 25 % Pozzolanica Solena ($\omega_2 = 0,394$)							
Age of specimens [days]	Dimensions (height, width and length) [mm]			Expansion of the length (ΔL) [mm/m]	Weight [g]	Density (D) (EN 12390-7) [kg/m ³]	Elastic modulus $E_d = D \cdot V^2 \cdot 0,83$ (EN 12504-1) [N/mm ²]
0 ⁽¹⁾	12,64	40,03	159,79	--	195,43	2.416	37.108
14 ⁽¹⁾	12,69	39,97	159,74	-0,313	195,59	2.412	38.029
28 ⁽¹⁾	12,70	39,96	159,72	-0,438	195,90	2.415	40.011
56 ⁽¹⁾	12,75	39,97	159,70	-0,563	195,97	2.405	41.503
90 ⁽¹⁾	12,80	39,98	159,70	-0,563	196,87	2.404	42.977
180 ⁽¹⁾	12,88	39,94	159,77	-0,125	198,09	2.406	44.880

⁽¹⁾ One of the three specimens broke during the last period.**Table B4.3:** Sulphate resistance assessment (reference storage at 20 °C).

Saturated Ca(OH)₂ solution at 5 °C (reference storage at 5 °C).							
Assessed characteristics (mean value of 3 specimens) for CEM IV/A (V) 42.5R ($\omega_2 = 0,45$)							
Age of specimens [days]	Dimensions (height, width and length) [mm]			Expansion of the length (ΔL) [mm/m]	Weight [g]	Density (D) (EN 12390-7) [kg/m ³]	Elastic modulus $E_d = D \cdot V^2 \cdot 0,83$ (EN 12504-1) [N/mm ²]
0	13,04	39,72	159,72	--	198,89	2.401	36.381
14	13,05	39,75	159,60	-0,751	199,10	2.405	36.972
28	13,03	39,88	159,51	-1,315	199,53	2.406	37.677
56	12,95	39,80	159,52	-1,252	200,39	2.439	41.744
90	12,93	39,77	159,55	-1,064	200,65	2.447	42.602
180 ⁽¹⁾	12,85	39,82	159,52	-1,252	199,82	2.451	44.003
⁽¹⁾ One of the three specimens broke during the last period.							
Assessed characteristics (mean value of 3 specimens) for 75 % CEM II/A-LL 42.5R + 25 % Pozzolanica Solena ($\omega_2 = 0,394$)							
Age of specimens [days]	Dimensions (height, width and length) [mm]			Expansion of the length (ΔL) [mm/m]	Weight [g]	Density (D) (EN 12390-7) [kg/m ³]	Elastic modulus $E_d = D \cdot V^2 \cdot 0,83$ (EN 12504-1) [N/mm ²]
0	11,11	39,92	159,69	--	170,25	2.402	36.306
14	11,22	39,85	159,59	-0,626	171,45	2.399	37.045
28	11,33	39,89	159,62	-0,438	172,26	2.385	37.640
56	11,29	39,91	159,68	-0,063	172,19	2.394	40.618
90	11,20	39,87	159,71	0,125	173,50	2.432	43.423
180	11,27	39,96	159,77	0,501	175,26	2.434	45.143

Table B4.4: Sulphate resistance assessment (reference storage at 5 °C).