Deutsches Institut für Bautechnik

Approval body for construction products and types of construction

Bautechnisches Prüfamt

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European Technical Assessment

ETA-19/0458 of 19 June 2020

English translation prepared by DIBt - Original version in German language

General Part

Technical Assessment Body issuing the European Technical Assessment:	Deutsches Institut für Bautechnik
Trade name of the construction product	Rapid Set
Product family to which the construction product belongs	Belitic Calcium Sulphoaluminate Cement
Manufacturer	CTS Cement Manufacturing Corporation 12442 Knott Street GARDEN GROVE, CA 92841 USA
Manufacturing plant	No 10
This European Technical Assessment contains	13 pages including 1 annex with 8 pages, which forms an integral part of this assessment
This European Technical Assessment is issued in accordance with Regulation (EU) No 305/2011, on the basis of	EAD 150024-00-0301

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Specific part

1 Technical description of the product

The "Belitic Calcium Sulphoaluminate Cement (Belitic CSA-Cement)" referred to in this document is a cement with rapid hardening features. This cement is not covered by the harmonized European Standard EN 197-1.

The belitic calcium sulphoaluminate clinker (belitic CSA-Clinker) is made by sintering a precisely specified mixture of raw materials (raw meal, paste or slurry) containing elements, usually expressed as oxides, CaO, Al_2O_3, SiO_2, Fe_2O_3, SO_3 and small quantities of other materials.

The belitic CSA-Clinker is composed mainly by $2CaO \cdot SiO_2$ (Belite) and by $C_4A_3\overline{C}$ or $C_4(A,F)_3\overline{C}$ (Ye'elimite).

The content of Belite in the clinker is approx. 58 % by mass and the content of Ye'elimite in the clinker is approx. 31 % by mass.

The composition of the belitic CSA-Cement "Rapid Set" is listed below:

Belitic CSA-Clinker	88,0 ± 7,0 % by mass
Cement CEM I and II acc. EN 197-1	-
Calcium sulfate (as defined in EN 197-1, clause 5.4)	12,0 ± 7,0 % by mass
Limestone (as defined in EN 197-1, clause 5.2.6)	-
Fly ash (as defined in EN 197-1, clause 5.2.4)	-
Minor additional constituents (as defined in EN 197-1, clause 5.3)	< 5 % by mass[1]
Additives (as defined in EN 197-1, clause 5.5)	< 2 % by mass[2]
Of which organic additives (as defined in EN 197-1, clause 5.5)	< 0,2 % by mass

The belitic CSA-Cement "Rapid Set" complies with the specifications of EN 197-1 except the points in Table 1.

Table 1: Comparison between belitic CSA-Cement characteristics and specifications of EN 197-1

Belitic CSA-Cement properties	Specifications of EN 197-1
This cement contains as constituent a belitic CSA-Clinker (81 – 98 %)	Only Portland cement clinker
Initial setting time can be < 45 min	Initial setting time ≥ 45 min (clause 7.1.2)
Sulfate (as SO_3) content > 4 %	Sulfate (as SO_3) content ≤ 4,0 % by mass (clause 7.3, table 4)

[1] The residues of belitic CSA-Clinker process can be integrated as minor additional constituents

[2] EN 197-1 clause 5.5 specifies: The total quantity of additives shall not exceed 1,0 % by mass of the cement (except for pigments). The quantity of organic additives on a dry basis shall not exceed 0,2 % by mass of the cement. A higher quantity may be incorporated in cements provided that the maximum quantity, in %, is declared on the packaging and/or the delivery note

2 Specification of the intended use in accordance with the applicable European Assessment Document

The belitic CSA-Cement "Rapid Set" is cement for production of concrete, mortar, grouts and other mixes including in particular cast-in-situ and prefabricated structural concrete conforming to EN 206.

The belitic CSA-Cement "Rapid Set" is especially characterized by a rapid hardening.

Especially the belitic CSA-Cement "Rapid Set" is characterized by an evidently high resistance against sulfate attack on concrete.

The verifications and assessment methods on which this European Technical Assessment is based lead to the assumption of a working life of concrete incorporating the belitic CSA-Cement "Rapid Set" of at least 50 years. The indications given on the working life cannot be interpreted as a guarantee given by the producer, but are to be regarded only as a means for choosing the right products in relation to the expected economically reasonable working life of the works.

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

3.1 Mechanical resistance and stability (BWR 1)

Essential characteristic	**Performance**
Early strength (3 h)	$R_{C,3h}$ = 30 MPa
Standard strength (28 days)	57,5 MPa (≥ 42,5 R according to EN 197-1)
Calcium sulphoaluminate (Ye'elimite) content in the cement	(29 ± 6) % by mass
Belite content (C_2S) in the cement	(51 ± 7) % by mass
Cement composition	BCSAK = (88,0 ± 7,0) % by mass $C\bar{S}$ = (12,0 ± 7,0) % by mass
Initial setting time	≥ 13 min
Soundness	Passed
Sulfate content (expressed as SO_3)	14,0 ± 2,0 % by mass
Chloride content	Passed
Density	(3,0 ± 0,2) g/cm³
Fineness (Blaine)	(5800 ± 800) cm²/g
Effect of different storage temperatures of mortar which hardened under standard conditions	See Annex A, clause A1
Shrinkage - Concrete Method	Shr_C: ε_{180d} = -0,13 mm/m; Δw_{180d} = -2,17 % by mass
Effect of different curing temperatures on mortar at early age	See Annex A, clause A2
Sulfate Resistance (External sulfate attack) – Flat prism method	S_{FPM} = See Annex A, clause A3
Carbonation of concrete	No performance assessed.
Resistance to chloride penetration	No performance assessed.

Essential characteristic	Performance
Freeze-thaw resistance (without de-icing agent) – CIF-Method	FT_{CIF}: S_n = 0,54 kg/m²; RDM = 94 %; f_{C28} = 59,2 MPa
Freeze-thaw resistance (with de-icing agent)	No performance assessed.

R_c = Compressive strength acc. to EN 196-1
BCSAK = Belitic Calcium Sulphoaluminate Clinker
$C\bar{S}$ = Calcium sulphate according to EN 197-1, clause 5.4
S_{FPM} = Sulfate resistance (Flat Prism Method)
Shr_C = Shrinkage - Concrete Method
ε_{180d} = Expansion (drying shrinkage) after 180 days
Δw_{180d} = Loss of mass after 180 days
FT_{CIF} = Freeze thaw test without de-icing agent (CIF-Method)
S_n = Scaling after 28 freeze thaw cycles
RDM = Relative Dynamic Modulus of Elasticity
f_{C28} = Compressive strength after 28 days

3.2 Hygiene, health and the environment (BWR 3)

Essential characteristic	Performance
Content, emission and/or release of dangerous substances	No performance assessed.

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

In accordance with EAD No. 150024-00-0301, the applicable European legal act is: 97/555/EC[3] amended by the Commission Decision 2010/683/EU[4].

The system to be applied is: 1+

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

Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited with Deutsches Institut für Bautechnik.

Issued in Berlin on 19 June 2020 by Deutsches Institut für Bautechnik

BD Dipl.-Ing. Andreas Kummerow
Head of Department

beglaubigt:
Schröder

[3] Official Journal of the European Communities L 229 of 20 August 1997
[4] Official Journal of the European Communities L 293 of 11 November 2010

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ANNEX A: Assessment

A1 Effect of curing temperature on mortar hardened under standard conditions

The testing procedure was done according to EAD 150024-00-0301, clause 2.2.12.

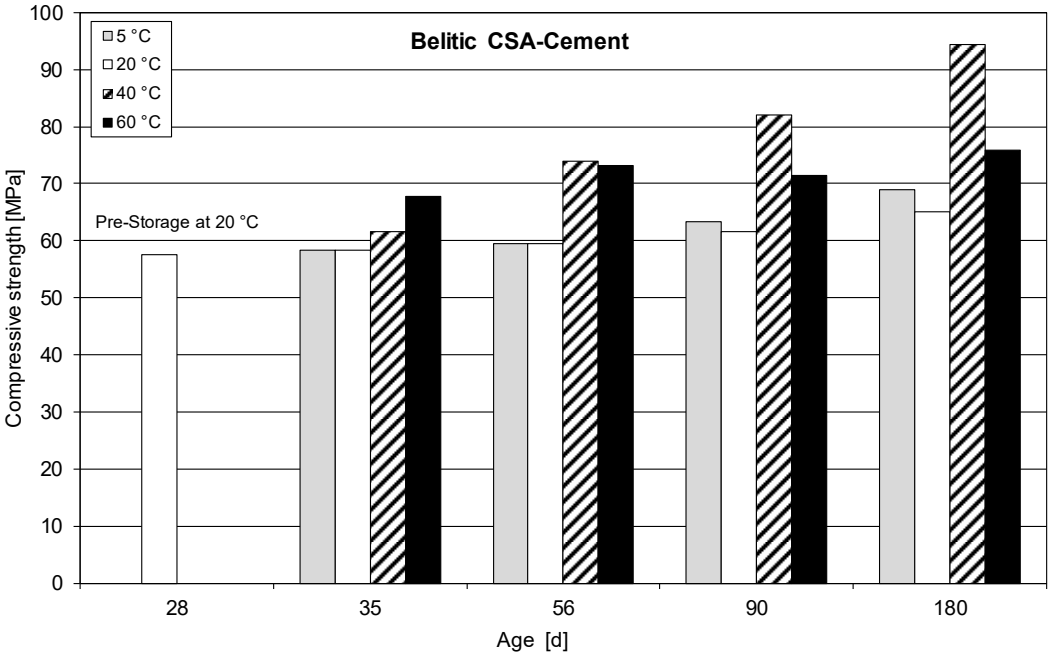

Figure A1.1: Compressive strength of mortar with belitic CSA-Cement "Rapid set" stored at 5°C 20°C, 40°C and 60°C

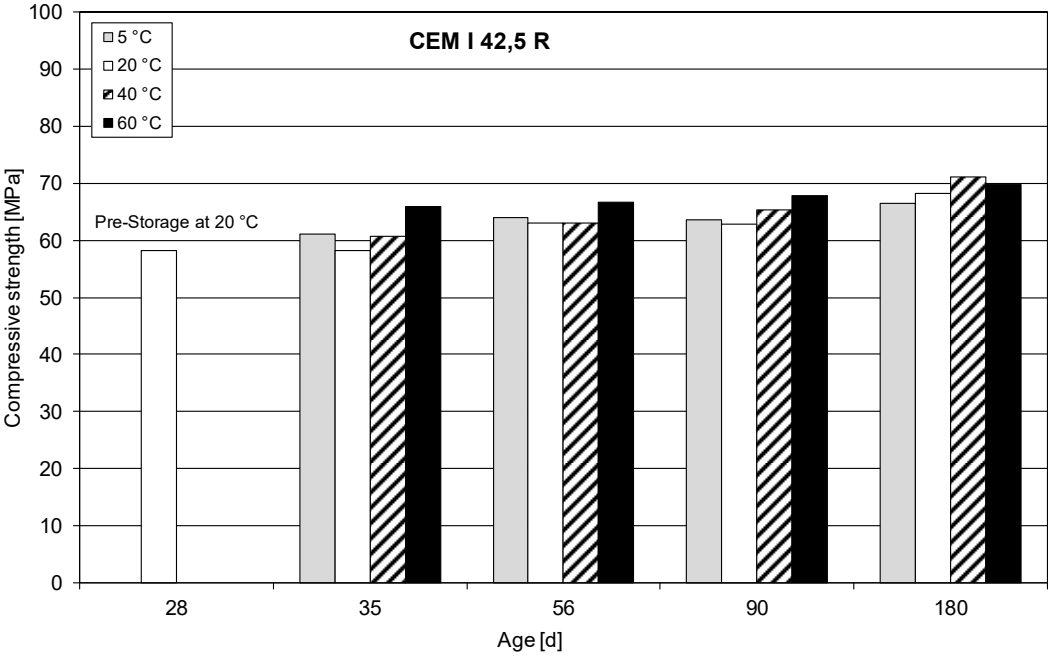

Figure A1.2: Compressive strength of mortar with CEM I 42,5 R stored at 5 °C 20 °C, 40 °C and 60 °C

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A2 Effect of curing temperature on mortar at early age

The testing procedure was done according to EAD 150024-00-0301, clause 2.2.14.

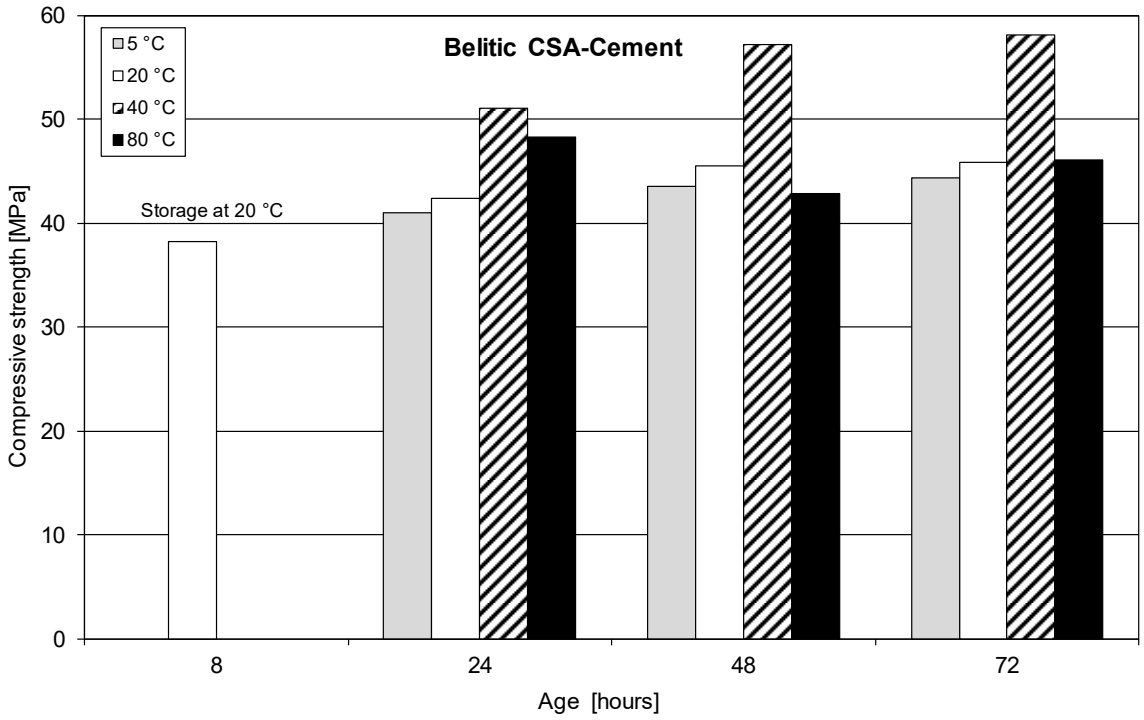

Figure A2.1: Compressive strength of mortar with belitic CSA-Cement "Rapid set" at 5 °C, 20 °C, 40 °C and 80 °C after 8 hours storage at 20 °C

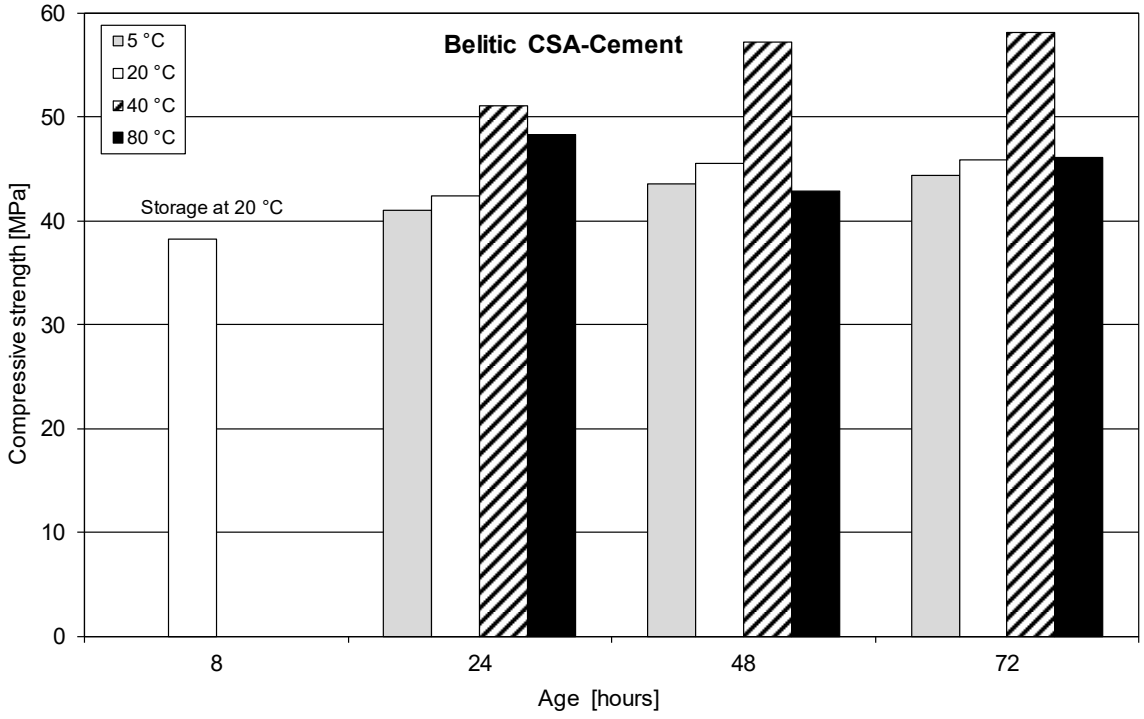

Figure A2.2: Compressive strength of mortar with CEM I 42,5 R at 5 °C, 20 °C, 40 °C and 80 °C after 8 hours storage at 20 °C

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A3 Sulfate resistance – Flat prism method

The testing procedure was done according to EAD 150024-00-0301, Annex A.

The elongation of the flat prisms was calculated as mean value from 3 specimens. The difference in elongation between the sulfate storage and the reference storage are given as expansion of the length. The expansion of the length for the different mortars and storages are given in Table A3.1.

Table A3.1: Expansion of length of the mortar flat prisms

	Expansion of the length [mm/m] after				
	14 days	28 days	56 days	90 days	180 days
Belitic CSA-Cement "Rapid Set" - storage at 20 °C					
Na_2SO_4-solution	0,00	0,02	0,03	0,04	0,05
$Ca(OH)_2$-solution	-0,06	-0,04	-0,04	-0,03	-0,03
ΔL	0,06	0,06	0,07	0,07	0,08
Belitic CSA-Cement "Rapid Set" - storage at 5 °C					
Na_2SO_4-solution	-0,21	-0,20	-0,16	-0,13	-
$Ca(OH)_2$-solution	-0,17	-0,17	-0,13	-0,13	-
ΔL	-0,04	-0,03	-0,03	0,00	-
CEM III/B 42,5 N-SR - storage at 20 °C					
Na_2SO_4-solution	0,04	0,03	0,08	0,12	0,15
$Ca(OH)_2$-solution	0,03	0,00	0,07	0,08	0,09
ΔL	0,01	0,03	0,01	0,04	0,06
CEM III/B 42,5 N-SR - storage at 5 °C					
Na_2SO_4-solution	-0,13	-0,11	-0,03	0,02	-
$Ca(OH)_2$-solution	-0,13	-0,10	0,06	-0,07	-
ΔL	0,01	-0,01	0,03	0,09	-
CEM I 42,5 N-SR3 - storage at 20 °C					
Na_2SO_4-solution	0,04	0,09	0,15	0,24	0,54
$Ca(OH)_2$-solution	0,01	0,04	0,04	0,05	0,09
ΔL	0,03	0,05	0,11	0,19	0,45
CEM I 42,5 N-SR3 - storage at 5 °C					
Na_2SO_4-solution	-0,08	-0,01	0,13	0,41	-
$Ca(OH)_2$-solution	-0,14	-0,08	-0,09	-0,07	-
ΔL	0,06	0,07	0,22	0,48	-

Table A3.2: Dynamic modulus of elasticity of the mortar flat prisms

	Dynamic modulus of elasticity in kN/mm² after					
	0 days	14 days	28 days	56 days	90 days	180 days
Belitic CSA-Cement "Rapid Set" - storage at 20 °C						
Na_2SO_4-solution	36,51	39,01	39,24	40,04	40,75	42,18
$Ca(OH)_2$-solution	35,98	36,67	36,93	37,16	37,97	40,69
Belitic CSA-Cement "Rapid Set" - storage at 5 °C						
Na_2SO_4-solution	36,30	38,01	38,28	38,70	39,00	-
$Ca(OH)_2$-solution	36,01	36,64	36,96	37,13	37,31	-
CEM III/B 42,5 N-SR - storage at 20 °C						
Na_2SO_4-solution	30,00	34,08	36,83	38,76	39,53	40,44
$Ca(OH)_2$-solution	30,53	32,86	36,15	38,48	39,68	40,66
CEM III/B 42,5 N-SR - storage at 5 °C						
Na_2SO_4-solution	30,56	32,56	33,11	33,82	34,63	-
$Ca(OH)_2$-solution	31,63	32,63	32,85	33,49	34,07	-
CEM I 42,5 N-SR3 - storage at 20 °C						
Na_2SO_4-solution	39,93	41,51	42,15	42,92	43,08	42,37
$Ca(OH)_2$-solution	40,48	41,35	41,90	42,77	43,45	44,03
CEM I 42,5 N-SR3 - storage at 5 °C						
Na_2SO_4-solution	36,40	37,74	38,13	38,06	37,79	-
$Ca(OH)_2$-solution	36,70	37,36	37,61	38,23	38,64	-

Table A3.3: Mass of the mortar flat prisms

	Mass in g after					
	0 days	14 days	28 days	56 days	90 days	180 days
Belitic CSA-Cement "Rapid Set" - storage at 20 °C						
Na_2SO_4-solution	152,78	153,13	153,06	153,20	152,83	152,83
$Ca(OH)_2$-solution	149,51	149,86	149,76	149,87	149,84	149,86
Belitic CSA-Cement "Rapid Set" - storage at 5 °C						
Na_2SO_4-solution	151,86	152,31	152,03	151,75	151,25	-
$Ca(OH)_2$-solution	150,30	150,54	150,85	150,76	150,67	-
CEM III/B 42,5 N-LH/SR - storage at 20 °C						
Na_2SO_4-solution	151,30	151,51	151,57	151,65	151,65	151,93
$Ca(OH)_2$-solution	151,69	151,67	151,69	151,73	151,85	152,06
CEM III/B 42,5 N-LH/SR - storage at 5 °C						
Na_2SO_4-solution	151,30	151,51	151,57	151,65	151,65	-
$Ca(OH)_2$-solution	151,69	151,67	151,69	151,73	151,85	-
CEM I 42,5 N-SR3 - storage at 20 °C						
Na_2SO_4-solution	153,60	153,76	153,86	154,14	154,70	155,22
$Ca(OH)_2$-solution	155,70	155,86	155,86	155,93	156,07	156,01
CEM I 42,5 N-SR3 - storage at 5 °C						
Na_2SO_4-solution	151,72	152,16	152,29	152,66	153,25	-
$Ca(OH)_2$-solution	149,51	149,86	149,79	149,87	149,84	-

Visual description of the specimens after sulphate storage respectively $Ca(OH)_2$ storage

After a testing period of 180 days respectively 90 days the specimens with belitic CSA-Cement "Rapid Set" and with the two reference cements show no expansion damages, cracks or flaking based on formation of thaumasite, see figures A3.1 to A3.12.

Figure A3.1: Specimens with belitic CSA-Cement "Rapid Set" after 180 days storage Na_2SO_4-solution at 20 °C

Figure A3.2: Specimens with belitic CSA-Cement "Rapid Set" after 180 days storage in $Ca(OH)_2$-solution at 20 °C

Figure A3.3: Specimens with belitic CSA-Cement "Rapid Set" after 90 days storage in Na_2SO_4-solution at 5 °C

Figure A3.4: Specimens with belitic CSA-Cement "Rapid Set" after 90 days storage in $Ca(OH)_2$-solution at 5 °C

Figure A3.5: Specimens with CEM III/B 42,5 N-SR after 180 days storage Na_2SO_4-solution at 20 °C

Figure A3.6: Specimens with CEM III/B 42,5 N-SR after 180 days storage in $Ca(OH)_2$-solution at 20 °C

Figure A3.7: Specimens with CEM III/B 42,5 N-SR after 90 days storage in Na_2SO_4-solution at 5 °C

Figure A3.8: Specimens with CEM III/B 42,5 N-SR after 90 days storage in $Ca(OH)_2$-solution at 5 °C

Figure A3.9: Specimens with CEM I 42,5 R-SR3 after 180 days storage Na_2SO_4-solution at 20 °C

Figure A3.10: Specimens with CEM I 42,5 R-SR3 after 180 days storage in $Ca(OH)_2$-solution at 20 °C

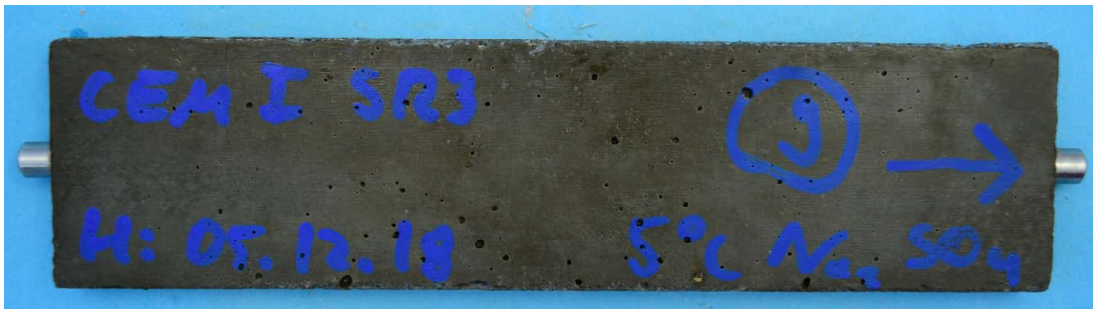

Figure A3.11: Specimens with CEM I 42,5 R-SR3 after 90 days storage in Na_2SO_4-solution at 5 °C

Figure A3.12: Specimens with CEM I 42,5 R-SR3 after 90 days storage in $Ca(OH)_2$-solution at 5 °C