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## ***Supplementary Material for***

### **Reactivity tests for supplementary cementitious materials: RILEM TC 267-TRM phase 1**

Xuerun Li<sup>1</sup>, Ruben Snellings, Mathieu Antoni, Natalia Mariel Alderete, Mohsen Ben Haha, Shashank Bishnoi, Ozlem Cizer, Martin Cyr, Klaartje De Weerd, Yuvaraj Dhandapani, Josée Duchesne, Johannes Haufe, Doug Hooton, Maria Juenger, Siham Kamali-Bernard, Sabina Kramar, Milena Marroccoli, Aneeta Mary Joseph, Anuj Parashar, Cedric Patapy, John L. Provis, Sergio Sabio, Manu Santhanam, Laurent Steger, Tongbo Sui, Antonio Telesca, Anya Vollpracht, Felipe Vargas, Brant Walkley, Frank Winnefeld, Guang Ye, Maciej Zajac, Shizhe Zhang, Karen L. Scrivener

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<sup>1</sup> X. Li, K.L. Scrivener, Laboratory of Construction Materials, Swiss Federal Institute of Technology in Lausanne (EPFL), , Station 12, CH-1015 Lausanne, Switzerland, e-mail: [karen.scrivener@epfl.ch](mailto:karen.scrivener@epfl.ch), [xuerun.li@epfl.ch](mailto:xuerun.li@epfl.ch)  
R. Snellings, Sustainable Materials Management, Flemish Institute of Technological Research (VITO), Boeretang 200, 2400 Mol, Belgium, email: [ruben.snellings@vito.be](mailto:ruben.snellings@vito.be)  
M. Antoni, Holcim Technology Ltd. Im Schachen, 5113 Holderbank, Switzerland  
A. Mary Joseph, Natalia Mariel Alderete, Magnel Laboratory for Concrete Research, Technologiepark Zwijnaarde 904, 9052 Ghent, Belgium  
M. Ben Haha, M. Zajac, HeidelbergCement Technology Center GmbH, Rohrbacher Str. 95, 69181 Leimen, Germany  
A. Parashar, S. Bishnoi, Department of Civil Engineering, Indian Institute of Technology Delhi, Hauz Khas, New Delhi 110 016, India  
Ö. Cizer, KU Leuven, Department of Civil Engineering, Kasteelpark Arenberg 40 - box 2448, 3001 Leuven, Belgium  
L. Steger, C. Patapy, M. Cyr, Institut National des Sciences Appliquées (INSA Toulouse), LMDC-Département Génie Civil, Avenue de Rangueil 135, 31077 Toulouse Cedex 4, France  
K. De Weerd, Department of Structural Engineering, Norwegian University of Science and Technology, Trondheim, Norway  
M. Santhanam, Y. Dhandapani, Department of Civil Engineering, IIT Madras, 600036 Chennai, India  
J. Duchesne, Department of Geology and Geological Engineering, Université Laval, QC, Canada G1V 0A6  
J. Haufe, A. Vollpracht, Institute of Building Materials Research, RWTH Aachen University, Schinkelstr. 3, 52062 Aachen, Germany  
D. Hooton, O. Perebatova, Dept. of Civil Engineering, 35 St. George St., Toronto, ON, Canada M5S1A4  
M. Juenger, Department of Civil, Architectural and Environmental Engineering, University of Texas at Austin, 301 E. Dean Keeton St., Austin, TX 78712, USA  
S. Kamali-Bernard, Institut National des Sciences Appliquées (INSA Rennes), Laboratoire de Génie Civil et Génie Mécanique/LGCGM, 20, Avenue des Buttes de Coësmes, CS 70839, F – 35708 Rennes Cedex 7, France  
S. Kramar, ZAG-Slovenian National Building and Civil Engineering Institute, Dimičeva ulica 12, 1000 Ljubljana, Slovenia  
M. Marroccoli, A. Telesca, Scuola di Ingegneria, Università degli Studi della Basilicata, Viale dell'Ateneo Lucano, 10, 85100 Potenza, ITALY  
J.L. Provis, B. Walkley, Department of Materials Science and Engineering, The University of Sheffield, Sheffield S1 3JD, United Kingdom  
S. Sabio, Lafarge Research Center, 95 Rue du Montmurier, 38290 France  
T. Sui, B. Wang, Sinoma Research Institute, Sinoma International Engineering Co., Ltd, No. 16 Wangjing North Road, Chaoyang District, Beijing 100102, P.R. China  
F. Vargas, Department of Construction Engineering and Management, School of Engineering, Pontificia Universidad Católica de Chile, Vicuña Mackenna 4860, Casilla 306, Correo 22, Santiago, Chile  
F. Winnefeld, Laboratory for Concrete and Construction Chemistry, Empa, Swiss Federal Laboratories for Materials Science and Technology, Überlandstrasse 129, 8600 Dübendorf, Switzerland  
G. Ye, S. Zhang, Microlab/Section Materials & Environment, Faculty of Civil Engineering and Geosciences, Delft University of Technology, Building 23, Stevinweg 1, 2628 CN Delft, The Netherlands

This report was prepared by members within RILEM TC 267-TRM “Tests for Reactivity of Supplementary Cementitious Materials”. The report has been reviewed and approved by all members of the RILEM TC 267-TRM.

TC membership:

TC Chair: Karen L. Scrivener.

TC Deputy Chair: Ruben Snellings.

TC Members: Natalia ALDERETE, Mathieu ANTONI, Mohsen BEN HAHA, Susan BERNAL LOPEZ, Shashank BISHNOI, Özlem CIZER, Martin CYR, Nele DE BELIE, Klaartje DE WEERDT, Yuvaraj DHANDAPANI, Josée DUCHESNE, Pawel DURDZINSKI, Johannes HAUFE, R. Doug HOOTON, Edgardo IRASSAR, Aneeta Mary JOSEPH, Maria C. Garci JUENGER, Siham KAMALI-BERNARD, Sabina KRAMAR, Xuerun LI, Milena MARROCCOLI, Thomas MATSCHEI, Toyoharu NAWA, Marta PALACIOS, Anuj PARASHAR, Cédric PATAPY, Malene PEDERSEN, John L. PROVIS, Serge SABIO, Manu SANTHANAM, Karen SCRIVENER, Ruben SNELLINGS, Laurent STEGER, Tongbo SUI, Antonio TELESCA, Dr. Karl - Christian THIENEL, Felipe VARGAS, YurY VILLAGRAN ZACCARDI, Anya VOLLPRACHT, Brant WALKLEY, Frank WINNEFELD, Guang YE, Maciej ZAJAC, Shizhe ZHANG

In this supplementary material, material characteristics, technical details on the methods, and supplementary results are provided.

## **1 Material characteristics**

The physical, chemical and mineralogical properties of the selected SCMs and cements are given below. The particle size distributions (PSD) measured by laser diffractometry are presented in Figure A1. The chemical composition of SCMs determined by XRF, the density, Blaine fineness and the summary data of the particle size distributions are given in Table A1. Table A2 and A3 present the mineralogical composition of the tested SCMs. In Table A4 the chemical composition, Blaine fineness and particle size distribution data of the cements used for benchmark test are collected, and their mineralogical composition determined by X-ray powder diffraction (XRD) is given in Table A5.

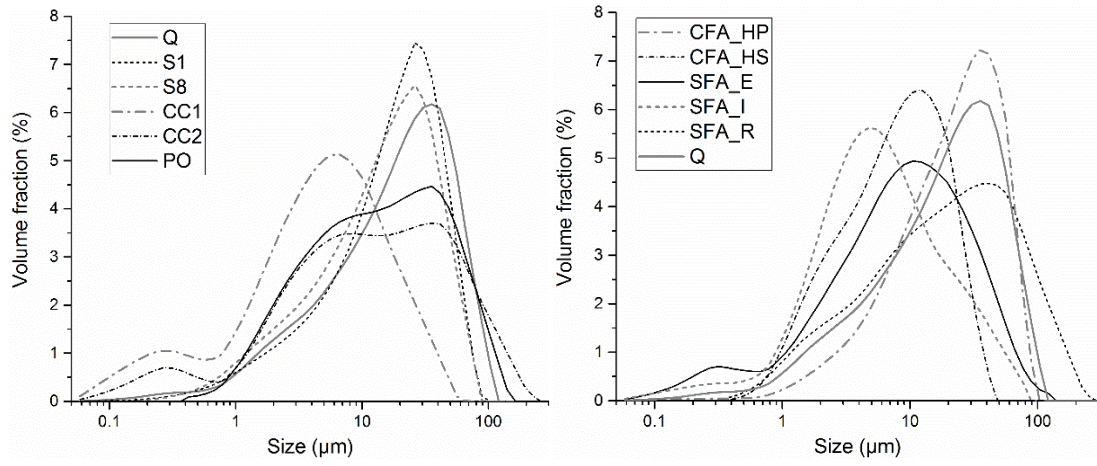


Figure A1 PSD of the SCMs

Table A1 Origin, chemical composition (%) and the characteristics of the SCMs

Content (wt.%)	Calcined clay		Slag		Fly ash					Pozzolan	Quartz
	CC1	CC2	S1	S8	CFA_P	CFA_S	SFA_E	SFA_I	SFA_R	Po	Q
Origin	U.S.	India	France	India	Poland	Bosnia & Hercegovina	India	India	Germany	Germany	Belgium
SiO <sub>2</sub>	52.00	53.46	35.72	34.09	46.77	47.61	70.83	58.63	54.31	55.98	99.28
Al <sub>2</sub> O <sub>3</sub>	43.80	34.88	11.94	19.87	25.87	21.90	24.36	30.16	22.72	16.48	
TiO <sub>2</sub>	1.53	2.35	0.51	0.90	1.02	0.73	1.48	1.70	1.08	0.80	0.04
MnO		0.01	0.23	0.09	0.03	0.05	0.05	0.04	0.05	0.19	
Fe <sub>2</sub> O <sub>3</sub>	0.33	3.39	0.84	0.45	5.45	8.25	2.24	4.10	10.28	5.07	0.03
CaO	0.03	0.13	41.38	33.01	13.35	15.46	0.06	1.13	4.29	3.03	
MgO	0.01	0.09	7.45	9.73	0.94	2.17	0.23	0.75	1.47	1.90	0.05
K <sub>2</sub> O	0.14	0.23	0.27	0.84	0.19	1.61	0.64	1.47	2.08	4.40	0.10
Na <sub>2</sub> O	0.29	0.17	0.26	0.25	0.05	0.33	0.10	0.08	0.87	4.21	0.17
SO <sub>3</sub>	0.10	0.03	1.38	0.75	1.61	1.08	0.00	0.00	0.32	0.06	0.04
P <sub>2</sub> O <sub>5</sub>	0.16	0.16		0.02	0.17	0.24	0.05	0.18	0.55	0.19	0.03
L.O.I. 950 °C	1.50	5.00	0.02								0.15
L.O.I. 1050 °C					3.71	0.05		0.82	1.32	7.31	
Na <sub>2</sub> O eq.	0.38	0.33	0.44	0.80	0.18	1.39	0.52	1.05	2.24	7.11	0.00
MAC [cm <sup>2</sup> /g]	34.81	40.88	72.02	64.15	55.76	64.65	39.98	44.83	59.08	48.39	34.84
Density (g/cm <sup>3</sup> )	2.11	2.62	2.48	2.66	2.89	2.80	2.47	2.10	2.17	2.29	2.63
Blaine (m <sup>2</sup> /kg)	n/a	n/a	348	440	327	370	691	442	308	245	321
Dv <sub>10</sub> (µm)	0.4	1.3	2.8	2.2	4.5	1.7	1.2	1.3	2.3	2.2	2.5
Dv <sub>50</sub> (µm)	4.5	11.2	17.2	14.3	21.2	7.4	9.0	5.1	18.6	12.9	18.6
Dv <sub>90</sub> (µm)	18.2	64.4	42.5	40.1	52.3	20.6	35.6	24.3	81.2	55.7	53.8

Notes: L.O.I. refers to loss on ignition; MAC, mass absorption coefficient; Na<sub>2</sub>O eq., Na<sub>2</sub>O equivalent; Blaine, Blaine Specific surface-Blaine method; Dv<sub>10</sub>, Dv<sub>50</sub>, and Dv<sub>90</sub> refer to the specific size at the accumulative volume at 10, 50 and 90 %.

Table A2 Mineralogical composition (wt.%) of the calcined clays and the slags

Category	Calcined clays		Slags	
	CC1	CC2	S1	S8
Anatase	1.4	1.3		
Calcite	0.3		1.4	1.2
Gehlenite			1.5	6.2
Halloysite	1.6			
Hematite		1.7		
Kaolinite		12.0		
Mullite	2.5			
Muscovite 3T		2.0		
Quartz			0.5	0.5
Rutile		8.0		
Spinel				0.4
Amorphous	94.2	75.0	96.5	91.8
SUM	100.0	100.0	100.0	100.1

Table A3 Mineralogical composition (wt.%) of the fly ashes, the natural pozzolan and quartz

Category	Fly ash					Pozzolan	Quartz
	CFA_P	CFA_S	SFA_E	SFA_I	SFA_R	PO	Q
Analcime		0.0				13.8	
Anhydrite	2.3	1.6			1.3		
Ankerite						0.8	
C <sub>3</sub> A_cubic	0.7	0.3					
C <sub>2</sub> S_alpha	0.9						
C <sub>2</sub> S_beta		2.4					
Chabazite						6.9	
Gehlenite	4.2						
Halite potassian	1.4				0.0		
Hematite		1.9	0.2		1.5		
Lime	0.7	1.4					
Magnetite					1.4		
Mullite			18.5	31.8	11.6		
Muscovite-2M1						13.4	
Phillipsite-K						7.8	
Quartz	18.5	2.1	12.8	13.7	8.8		98.8
Sanidine						20.4	
Amorphous	70.9	90.1	68.5	54.5	75.0	36.8	1.2
SUM	99.6	99.8	100.0	100.0	99.5	99.9	100.0

Table A4 Chemical composition (wt.%) of the cements used for benchmark test

Type	CEM I 42.5 N	Lab. cement	CEM I 42.5 R	CEM I 42.5 R	P I 42.5	CEM I 42.5 N
Label	CEM_a	CEM_b	CEM_c	CEM_d	CEM_e	CEM_f
SiO <sub>2</sub>	19.56	19.08	19.76	20.62	20.84	19.71
Al <sub>2</sub> O <sub>3</sub>	4.49	5.31	5.44	5.42	5.09	4.44
TiO <sub>2</sub>	0.24	0.27	0.23	0.29	0.22	0.28
MnO	0.08	0.05	0.06	0.05	0.05	0.06
Fe <sub>2</sub> O <sub>3</sub>	3.14	3.77	3.01	2.51	3.31	2.92
CaO	63.56	64.45	61.09	62.85	63.28	63.13
MgO	1.68	1.66	2.74	1.50	2.82	1.57
K <sub>2</sub> O	0.80	1.24	1.58	0.79	0.79	0.80
Na <sub>2</sub> O	0.20	0.28	0.15	0.21	0.06	0.26
SO <sub>3</sub>	2.98	3.12	3.93	3.19	2.39	2.65
P <sub>2</sub> O <sub>5</sub>	0.17	0.28	0.16	0.13	0.07	0.10
L.O.I. 950 °C			1.20	2.06		3.42
L.O.I. 1050 °C	2.87	0.43			1.45	
Na <sub>2</sub> O eq.	0.73	1.10	1.19	0.73	0.58	0.79
Blaine (m <sup>2</sup> /kg)	289	351	433	346	390	343
Dv <sub>10</sub> (µm)	1.9	1.2	1.2	1.4	1.2	2.7
Dv <sub>50</sub> (µm)	18.2	14.7	11.4	14.2	14.2	19.3
Dv <sub>90</sub> (µm)	55.5	49.2	34.8	41.4	48.3	56.2

Table A5 Mineralogical composition (wt.%) of the cements

Sample ID	CEM_a	CEM_b	CEM_c	CEM_d	CEM_e	CEM_f
C <sub>3</sub> S	65.7	68.3	57.8	57.9	68.6	62.7
C <sub>2</sub> S	11.5	6.9	14.3	14.8	7.4	12.2
C <sub>3</sub> A	3.5	7.0	7.5	10.3	7.9	6.1
C <sub>4</sub> AF	8.4	8.5	7.6	5.5	7.9	6.9
Lime	0.2	0.7	1.2	0.2	0.4	0.1
Portlandite	0.5	0.2	1.9	0.4	0.9	1.4
Periclase	0.2	0.1	0.8	0.3	0.8	0.3
Calcite	4.1			2.2		4.2
Quartz			0.3	0.5	0.5	
Gypsum	4.2	1.5	1.9	0.9	2.0	2.9
Bassanite	1.4	1.3	2.8	4.2	3.1	3.0
Anhydrite	0.3	5.3	3.4	2.9		
SUM	99.9	99.7	99.6	100.0	99.5	99.8

## 2 Methods

### 2.1 Quantitative phase analysis by X-ray powder diffraction

XRD data were collected on dried powder using PANalytical X’pert pro working at 45 kV and 40 mA using Cu K $\alpha$  radiation. Incident beam Soller slits of 0.04 rad were used and the incident divergence slit was fixed at 0.5°. Air scattering was reduced using a beam knife. The receiving Soller slits limiting the axial divergence to 0.04 radians were positioned in the diffracted beam path. A X’Celerator linear position-sensitive X-ray detector with a length of 2.122 °2 $\theta$  was used for data acquisition. Samples were scanned on a spinning sample stage between 5 to 70° using continuous scanning mode. Powder samples were back-loaded gently into sample holder with a diameter of 28 mm and measured with 0.0356 °/s, resulting in a total measurement time of about 30 min per scan. Rutile was used as the external standard. Rietveld analysis was carried out using PANalytical HighScore Plus (version 4.2) following [1].

### 2.2 Gypsum and superplasticiser dosage for mortar compressive strength testing

For mortar compressive strength testing 2.0 wt.% and 0.60-0.80 wt.% (on total binder basis) of gypsum and superplasticizer were added for CC1 (calcined clay 1), respectively; 1.0 wt.% and 0.27-0.38 wt.% (on total binder basis) of gypsum and superplasticizer were added for CC2 (calcined clay 2), respectively.



### 2.3 R<sup>3</sup> system mix design and preparation

A weight ratio of SCM : Ca(OH)<sub>2</sub> = 1:3, and a solution/solids ratio of 1.2 were used. 0.3 M potassium was added as a mix of KOH and K<sub>2</sub>SO<sub>4</sub>. The potassium sulfate was added to promote the reaction of the SCMs and calcium carbonate (in the form of calcite) was added to provide carbonate as an excess counter anion for aluminate, and because sulfate concentrations are low in Portland cements beyond 1 day of hydration after the depletion of the calcium sulfate set retarder.

The binder materials (SCM, portlandite and calcite) were weighed according to Table 3 in the paper and mixed gently by hand for 2 min. The mixed dry powder, the solution as well as the calorimeter flasks were stored in closed containers at 40 °C in an oven overnight. The dry powder was then mixed with the solution at 1600 rpm for 2 min using a propeller mixer.

### 2.4 R<sup>3</sup> bound water test protocol

The R<sup>3</sup> pastes were cured in sealed plastic containers at 40 °C for 7 days. The sample was crushed by hand and small pieces (1-3 mm) were taken, and placed in an oven at 105 °C until reaching constant weight (~ 1 day). The dried samples were transferred to the cleaned crucibles with weight  $w_c$  (weight after heating at 350 °C for 1 hour). The initial weight of the crucible and the sample was recorded as  $w_0$ . The sample was then heated at 350 °C for 2 hours. The heated samples together with the crucibles were placed into a desiccator filled with silica gel for cooling. Finally, the weight of the cooled crucible including the heated sample was recorded:  $w_t$ . The bound water on dried basis (g/ 100 g dried paste) was calculated according to:

$$H_2O_{bound,dried} = \frac{w_0 - w_t}{w_0 - w_c} \times 100 \quad \text{Eq. (3)}$$

### 2.5 R<sup>3</sup> portlandite consumption protocol

The R<sup>3</sup> pastes were cured in a sealed container at 40 °C for 7 days. Approximately 3 g of the hydrated paste was sampled for further analysis. Material close to the upper surface of the hardened paste was avoided. Solvent exchange with isopropanol was used to stop the hydration reactions; the crushed sample was immersed in 100 mL of isopropanol for 15 min [2]. The suspension was stirred and poured gently on a Büchner filter to drain the isopropanol. The residue was rinsed using diethylether twice. The residue together with the filter was placed on a watch glass and dried at 40 °C for 8 min in a ventilated oven. The dried samples were stored in a low vacuum desiccator over silica gel.

Afterward, the dried samples were ground with a mortar and pestle just before thermogravimetric analysis. 50 mg of sample was introduced in the crucible which was heated from 30 °C to 950 °C at 10 °C/min. A protective nitrogen atmosphere at a flow rate of 50 mL/min was used. The portlandite content (in mg) was calculated using

the tangent method described by Lothenbach et.al. [3] (referred to the ignited weight, i.e. the sample mass at 950 °C).

Finally the portlandite (CH) consumption was calculated as g/100 g SCM:

$$m_{CH,consumption} = 100 \times \frac{(m_{0,CH,ignited} - m_{CH,ignited})}{m_{0,SCM,ignited}} \quad \text{Eq. (4).}$$

The residual CH ( $m_{CH,ignited}$ ) (g/ 100 g ignited base) in the R<sup>3</sup> mixes cured for 7 days was calculated:

$$m_{CH,ignited} = 100 \times \frac{\Delta m_{H_2O,CH} \times 74.09}{18.02 \times m_{950}} \quad \text{Eq. (5).}$$

where  $\Delta m_{H_2O,CH}$  is the weight loss (in mg) of the sample for portlandite using the tangent method, and  $m_{950}$  is the weight (in mg) of the sample at 950 °C. The value of 74.09 and 18.02 corresponds to the molar mass of Ca(OH)<sub>2</sub> and H<sub>2</sub>O expressed in gram per mole, respectively. The initial portlandite content and SCM content in the R<sup>3</sup> mix were designated as  $m_{0,CH,ignited}$  and  $m_{0,SCM,ignited}$  on the ignited basis respectively.

## 2.6 R<sup>3</sup> calorimetry protocol

The calorimeter was set to 40 °C followed by calibration of the heat flow channels. Then, sealed reference flasks (containing approx. 9.4 g of deionized water to match the heat capacity of the samples) were inserted into the calorimeter and the system was left to stabilize (~2 days). The baseline heat flows (both initial and final baseline) of each channel were determined for 180 min. Approximately 15 g of the freshly ( $m_p$ ) mixed R<sup>3</sup> model paste was introduced into heated sample flasks just after the mixing. All raw materials were preheated at 40 °C overnight before mixing. The heat release was recorded until 7 days. The cumulative heat (*Heat*) was calculated from 1.2 hours after the beginning of the calorimetry test. The total heat release  $H_{rescaled}$  was then reported in J/(g SCM) as following:

$$H_{rescaled} = \frac{Heat}{(m_p \times 0.0997)} \quad \text{Eq. (6),}$$

where *Heat* is the cumulative heat calculated (J), 0.0997 is the fraction of the SCMs in the paste sample.

## 2.7 R<sup>3</sup> chemical shrinkage protocol

4-6 replicate samples were used for all measurements. The fresh R<sup>3</sup> paste was added into the test vial (weight  $m_{vial}$ ) up to ~3 cm (half to two thirds of the container’s capacity) using a pipette and consolidated by 2~3 gentle taps. The test vial and cement paste were weighed and recorded as ( $m_{vial+paste}$ ). De-aerated water at 40°C was added carefully by letting the water flow along the side of the vial to completely fill the vial. The stopper with the inserted pipette was placed tightly in the test vial without introducing entrapped air bubbles. The container and the pipette were sealed using paraffin film. Two drops of paraffin oil were added on the top of the pipette

to limit evaporation. The samples were then placed in a water bath at 40 °C. The volumes were recorded for 14 days. More than 3 readings per day were taken for the first 3 days, afterwards one reading per day was made until 14 days. One participant used an automatic recording system (recording every 30 min) similar to the one reported by Costoya [4]. The water bath was covered with floating plastic spheres to decrease the water evaporation. Water at 40 °C was refilled into the water bath to maintain the water level.

Chemical shrinkage (mL/ g of SCM) was computed according to:

$$CS_{rescaled} = \frac{V_t - V_{max}}{(m_{vial+paste} - m_{vial}) \times 0.0997} \quad \text{Eq. (7)}$$

where  $V_t$  is the volume (in mL) at time t and  $V_{max}$  (in mL) is the stabilized volume (the maximum volume) within 30 min, and 0.0997 is the fraction of the SCMs in the paste sample.

### 3 Supplementary results

#### 3.1 Compressive strength results

The compressive strength results for the reference cements are given in Figure A2. Table A6 shows the averaged absolute compressive strength results for the cements blended with the SCMs, and Table A7 shows the relative compressive strength results.

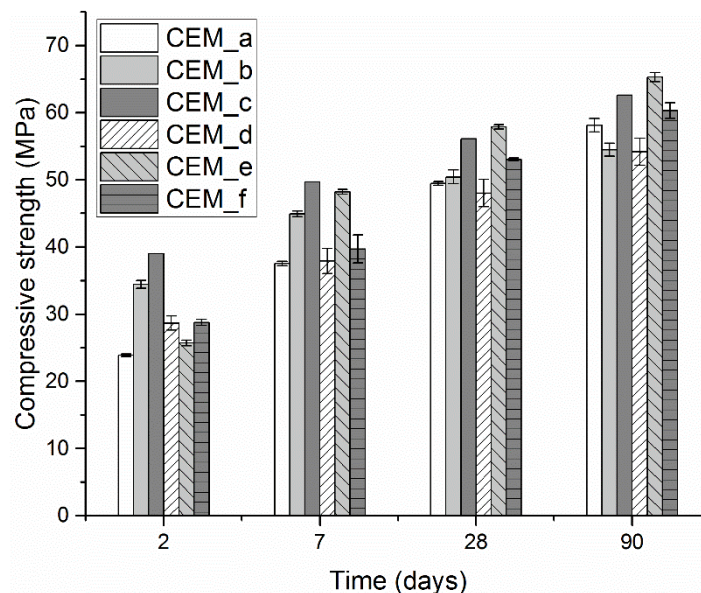


Figure A2 Compressive strength of the reference cements

Table A6 Compressive strength results of the mortar test, averaged results from all SCM blended cements tested

Ages (d)	2		7		28		90	
Samples names	MPa	$\sigma$	MPa	$\sigma$	MPa	$\sigma$	MPa	$\sigma$
PC	30.1	5.6	43.0	5.3	52.5	3.9	59.2	4.4
CC1	27.0	3.7	51.6	4.0	63.4	3.4	67.8	3.0
CC2	19.1	3.0	37.2	3.9	50.8	3.0	54.3	3.0
S1	18.5	3.7	34.8	3.4	53.6	5.6	63.4	6.0
S8	18.6	3.0	33.3	2.4	54.4	6.0	65.3	6.9
CFA_P	18.8	3.4	36.1	5.5	46.7	7.5	58.3	6.5
CFA_S	19.8	3.6	33.3	2.2	49.6	2.4	63.9	6.7
SFA_E	18.9	3.2	31.1	1.9	44.0	3.2	58.5	4.4
SFA_I	17.7	3.7	29.1	3.4	40.7	5.6	55.9	5.3
SFA_R	16.7	1.8	28.7	2.5	39.8	3.9	53.3	4.9
Po	17.3	2.0	30.7	1.9	44.3	1.4	51.7	3.0
Q	17.2	2.9	28.0	2.1	35.7	3.6	39.8	3.7

Table A7 Relative compressive strength of the mortar test, averaged results from all 6 cement tested.

Ages (d)	2		7		28		90	
Samples names	%	$\sigma$	%	$\sigma$	%	$\sigma$	%	$\sigma$
PC	0		0		0		0	
CC1	-9.4	10.5	21.2	13.4	21.3	11.5	15.1	8.9
CC2	-36.2	6.0	-12.6	11.4	-2.6	9.6	-7.7	9.7
S1	-38.3	6.9	-18.5	9.4	2.1	6.8	7.1	6.5
S8	-37.8	6.0	-22.0	7.0	3.4	5.7	10.2	6.6
CFA_P	-37.3	4.4	-15.0	17.4	-10.9	14.3	-1.6	6.7
CFA_S	-34.2	4.2	-21.8	9.6	-5.4	4.6	8.4	12.4
SFA_E	-36.7	5.4	-27.2	6.7	-15.9	6.5	-1.0	6.0
SFA_I	-41.2	5.7	-32.0	6.4	-22.7	7.6	-5.5	6.4
SFA_R	-40.6	4.1	-30.9	6.5	-23.1	5.7	-8.8	6.4
Po	-38.6	3.3	-25.9	4.8	-14.2	4.2	-11.4	4.5
Q	-42.6	3.8	-34.5	6.4	-32.1	3.0	-32.7	2.8

### 3.2 Standard reactivity test results

The results of the standard reactivity tests are summarized in Table A8.

For the Frattini test the reduction of CaO concentration (in %) was calculated by considering the distance of data points from the lime solubility curve on the vertical axis at the given [OH]<sup>-</sup> [5] using the following equation:

$$[CaO]_{max} = \frac{350}{[OH]^{-15}} \quad \text{Eq. (1),}$$

$$[CaO]_{reduction} = 100 \times \frac{[CaO]_{max} - [CaO]}{[CaO]_{max}} \quad \text{Eq. (2),}$$

where [CaO] and [OH] are the measured calcium and hydroxyl concentration (expressed in mmol/L), respectively. [CaO]<sub>max</sub> is the theoretical maximum [CaO] concentration calculated using the formula given in EN 196-5. The plot of calcium against hydroxyl ions is shown in Supplementary material Figure A3.

Table A8 Results of the standard reactivity tests.

Tests	Frattini test						Chapelle		Modified Chapelle		Reactive silica		IS 1727	
No. of participants	5						4		5		1		2	
Units	OH <sup>-</sup> (mmol/L)		[CaO] (mmol/L)		[CaO] reduction (%)		Ca(OH) <sub>2</sub> fixed (mg/g SCM)		Ca(OH) <sub>2</sub> fixed (mg/g SCM)		g/100 g SCM		MPa	
SCMs	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$
CC1	<b>22.1</b>	7.1	<b>0.7</b>	0.3	<b>98.4</b>	1.9	<b>927.4</b>	201.1	<b>1565.8</b>	223.0	<b>53.4</b>		<b>14.6</b>	1.1
CC2	<b>36.2</b>	6.4	<b>5.5</b>	2.7	<b>66.0</b>	19.0	<b>953.7</b>	636.6	<b>825.3</b>	58.7	<b>43.5</b>		<b>9.8</b>	2.3
S1	<b>52.8</b>	5.6	<b>11.9</b>	1.4	<b>-27.8</b>	21.5	<b>253.6</b>	324.1	<b>306.6</b>	467.9	<b>37.1</b>		<b>7.3</b>	2.2
S8	<b>49.5</b>	6.6	<b>9.3</b>	1.2	<b>9.4</b>	18.7	<b>383.7</b>	319.4	<b>385.2</b>	434.6	<b>34.1</b>		<b>13.4</b>	2.4
CFA_P	<b>42.1</b>	6.0	<b>8.2</b>	1.4	<b>36.7</b>	15.9	<b>542.1</b>	287.1	<b>446.3</b>	179.6	<b>31.0</b>		<b>8.7</b>	0.6
CFA_S	<b>44.2</b>	5.7	<b>6.5</b>	1.4	<b>47.0</b>	11.5	<b>653.0</b>	210.2	<b>622.5</b>	180.5	<b>42.3</b>		<b>12.9</b>	2.2
SFA_E	<b>42.6</b>	5.5	<b>8.5</b>	1.8	<b>33.4</b>	18.1	<b>974.4</b>	629.1	<b>732.6</b>	325.0	<b>54.1</b>		<b>8.9</b>	1.2
SFA_I	<b>47.8</b>	6.8	<b>10.2</b>	2.2	<b>2.9</b>	35.2	<b>885.9</b>	535.0	<b>433.3</b>	235.3	<b>33.1</b>		<b>8.5</b>	2.9
SFA_R	<b>47.1</b>	6.4	<b>8.3</b>	2.0	<b>24.3</b>	24.1	<b>812.5</b>	518.2	<b>558.5</b>	250.5	<b>42.3</b>		<b>8.1</b>	0.7
Po	<b>64.9</b>	6.6	<b>4.5</b>	0.8	<b>35.0</b>	15.8	<b>595.4</b>	357.8	<b>380.4</b>	129.3	<b>30.9</b>		<b>6.1</b>	0.9
Q	<b>48.5</b>	7.6	<b>12.9</b>	1.8	<b>-21.6</b>	24.4	<b>336.5</b>	179.9	<b>150.1</b>	232.2	<b>7.3</b>		<b>0.4</b>	0.0

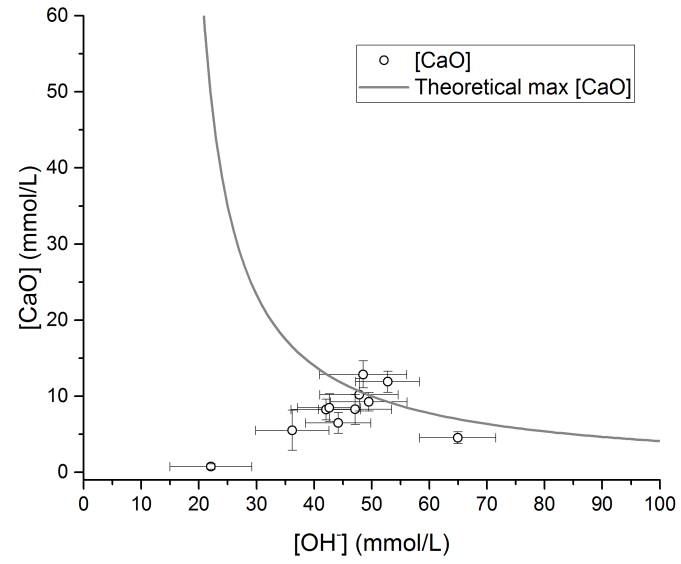


Figure A3. Plot of the Frattini test results

3.3 R<sup>3</sup> reactivity test results

The results of the R<sup>3</sup> reactivity tests are summarized in Table A9.

Table A9 Summary of the R<sup>3</sup> model outputs for bound water, portlandite consumption and selected outputs (1 and 7 days) for calorimetry and chemical shrinkages

Tests	Bound water		Portlandite consumption		Calorimetry				Chemical shrinkage			
No. of Participants	13		7		13				5			
Units	g/100 g dried basis		g/100 g SCMs		Heat at 3d (J/g SCMs)		Heat at 7d (J/g SCMs)		3d (mL/g SCM)		7d (mL/g SCM)	
SCMs	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$
CC1	<b>13.80</b>	3.2	<b>230.9</b>	8.7	<b>947.3</b>	111.7	<b>977.7</b>	108.5	<b>0.266</b>	0.036	<b>0.280</b>	0.035
CC2	<b>7.49</b>	1.6	<b>132.5</b>	14.9	<b>476.8</b>	66.9	<b>514.3</b>	73.0	<b>0.138</b>	0.027	<b>0.154</b>	0.030
S1	<b>4.84</b>	1.6	<b>71.2</b>	9.9	<b>432.4</b>	49.4	<b>503.8</b>	70.0	<b>0.107</b>	0.023	<b>0.124</b>	0.023
S8	<b>6.15</b>	1.3	<b>94.8</b>	12.5	<b>454.1</b>	45.7	<b>558.8</b>	67.3	<b>0.117</b>	0.027	<b>0.143</b>	0.032
CFA_P	<b>4.01</b>	0.8	<b>105.0</b>	9.4	<b>310.0</b>	43.1	<b>396.4</b>	45.1	<b>0.087</b>	0.011	<b>0.121</b>	0.011
CFA_S	<b>4.50</b>	1.0	<b>107.3</b>	19.3	<b>272.1</b>	94.6	<b>409.6</b>	138.4	<b>0.064</b>	0.016	<b>0.099</b>	0.016
SFA_E	<b>2.21</b>	1.0	<b>84.4</b>	27.3	<b>119.6</b>	13.1	<b>214.1</b>	30.6	<b>0.066</b>	0.012	<b>0.109</b>	0.022
SFA_I	<b>1.83</b>	0.8	<b>59.6</b>	15.5	<b>81.6</b>	21.4	<b>162.5</b>	28.6	<b>0.060</b>	0.015	<b>0.114</b>	0.021
SFA_R	<b>2.46</b>	1.1	<b>69.8</b>	15.7	<b>113.2</b>	23.9	<b>198.4</b>	51.0	<b>0.067</b>	0.018	<b>0.109</b>	0.023
Po	<b>3.20</b>	1.4	<b>60.7</b>	17.0	<b>116.7</b>	20.6	<b>161.6</b>	51.7	<b>0.077</b>	0.018	<b>0.106</b>	0.019
Q	<b>0.72</b>	0.6	<b>6.7</b>	10.5	<b>16.6</b>	18.8	<b>28.2</b>	47.6	<b>0.022</b>	0.006	<b>0.037</b>	0.016



The average and standard deviation of the cumulative heat release of the R<sup>3</sup> test systems are given in Figure A4.

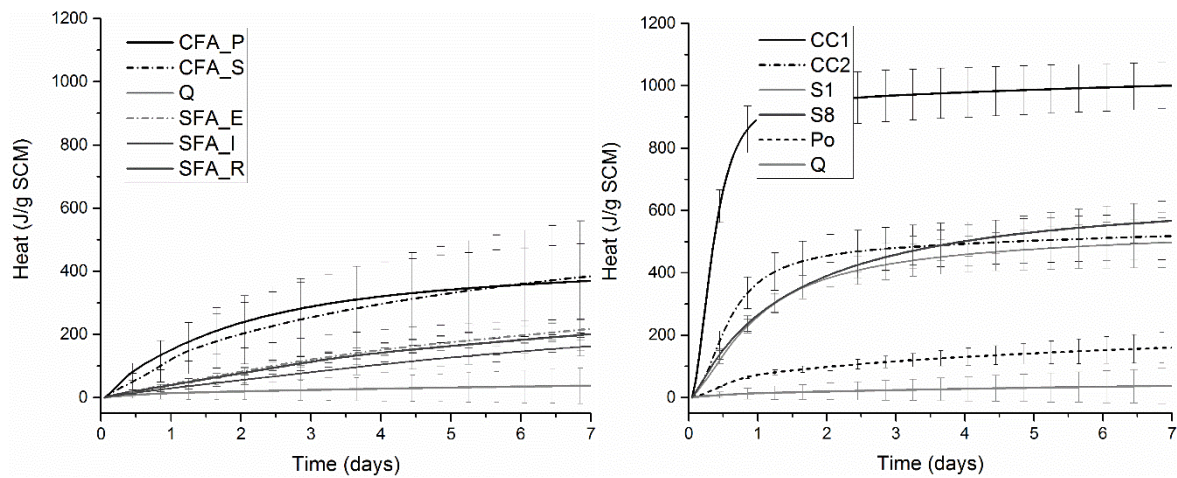


Figure A4. Cumulative heat release for the R<sup>3</sup> test

Correlation plots of the R<sup>3</sup> system heat release and bound water tests are shown in Figure A5. Correlation coefficients and equations are given in Table A10. Table A11 presents the reduced correlation matrix omitting the slag test results. Table A12 presents the R<sup>2</sup> index of linear correlation of the reactivity test results to the relative strength (refers to Quartz sample) at 7, 28 and 90 days for all SCMs tested.

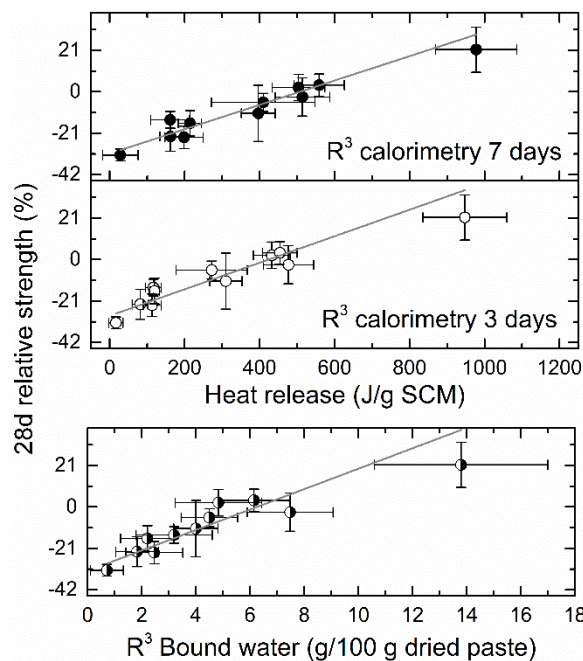


Figure A5. Correlation plots of the 28 days relative strength to the R3 heat release and bound water results.

Table A10. Fitted linear equations for methods showing good correlations ( $R^2 > 0.85$ )

Methods - x	28 relative strength (%) to PC - y	$R^2$
$R^3$ calorimetry 7 days, (J/g SCM)	$y = 0.0549 x - 29.691$	0.94
$R^3$ calorimetry 3 days, (J/g SCM)	$y = 0.0532 x - 25.259$	0.91
$R^3$ Bound water, (g/100 g dried sample)	$y = 3.8349 x - 26.95$	0.86

Table A11 Reduced  $R^2$  correlation coefficient matrix of the linear fitting of the tests against the relative strength at 7, 28 and 90 days for SCMs WITHOUT slag.

Relative strength at	Standard method					R3 model										
	Chapelle	Modified Chapelle	IS 1727	Frattini	Reactive silica	Bound water	CH consum.	Calorimetry (heat released)				Chemical shrinkage				
				[CaO] reduction				0.5d	1d	3d	7d	0.5d	1d	3d	7d	14d
7 days	0.41	0.82	0.49	0.78	0.27	0.96	0.92	0.95	0.96	0.98	0.96	0.95	0.95	0.95	0.89	0.75
28 days	0.53	0.84	0.70	0.93	0.43	0.93	0.96	0.82	0.86	0.92	0.95	0.83	0.84	0.87	0.85	0.75
90 days	0.62	0.59	0.95	0.65	0.69	0.46	0.69	0.36	0.37	0.47	0.59	0.37	0.37	0.43	0.56	0.67

Table A12  $R^2$  index of linear correlation of the reactivity test results to the relative strength (compared to Quartz reference) at 7, 28 and 90 days for all SCMs tested

Relative strength at	Standard method					R3 model										
	Chapelle	Modified Chapelle	IS 1727	Frattini	Reactive silica	Bound water	CH consum.	Calorimetry (heat released)				Chemical shrinkage				
				[CaO] reduction				0.5d	1d	3d	7d	0.5d	1d	3d	7d	14d
7 days	0.20	0.74	0.39	0.53	0.27	0.93	0.89	0.95	0.95	0.91	0.86	0.93	0.94	0.92	0.87	0.72
28 days	0.04	0.47	0.61	0.31	0.34	0.86	0.74	0.72	0.80	0.91	0.94	0.77	0.77	0.81	0.76	0.55
90 days	0.04	0.29	0.82	0.18	0.53	0.44	0.51	0.31	0.35	0.50	0.62	0.36	0.34	0.42	0.50	0.48

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### **Compliance with ethical standards**

### **Conflict of interest**

All co-authors are members in RILEM TC 267-TRM. None of the co-authors has financial conflict of interest.

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