

# TC 281-CCC – Carbonation of concrete with supplementary cementitious materials

## Meeting 6, Friday 4 September 2020, 13.30-16.30 (UK time!) RILEM week Sheffield, UK – online meeting

Zoom link: <https://zoom.us/j/94882628064?pwd=RWpYeHhKNUpsUTlab2ZsVTFpTzZJUT09>  
Passcode: 142203

### Agenda

*Welcome and short introduction of participants*

*Update on membership of the TC / new members*

*Approval of the minutes of meeting 5, Guimaraes, 09/03/2020*

*Feedback on the status of the working group activities by the working group chairs or their representatives / presentations related to the WG work*

**WG4:** *Effects of combined actions: load + carbonation (Ling Wang, Juan Li, Yao Yan)*

- *Status of the development of the loading devices and first round of the inter-laboratory comparison (Juan Li): 10'*

**WG1 and WG2:** *Correlation between atmospheric carbonation and carbonation induced by accelerated testing at high CO<sub>2</sub> concentrations (Barbara Lothenbach, Elke Gruyaert, Philip Van den Heede) / Effect of SCMs on natural and accelerated carbonation of blended Portland cements (Stefanie von Greve-Dierfeld, Leon Black)*

- *Status of the State-of-the-art paper: RILEM TC 281 – Understanding the Carbonation of Concretes with Supplementary Cementitious Materials (Stefanie von Greve-Dierfeld): 5'*
- *Status of the paper: Critical review of existing standardised test methods to determine carbonation resistance of concrete with supplementary cementitious materials (Susan Bernal): 5'*
- *Status of the inter-laboratory test: first results, delays and adjusted timing, planning (Elke Gruyaert): 15'*

**WG3:** *Modelling of carbonation (Bruno Huet, Christoph Gehlen)*

- *Status of activities of WG3 and future plans (Bruno Huet): 15'*

**WG5:** *Effect of carbonation on corrosion of concrete with SCMs (Ueli Angst, Fabrizio Moro)*

- *Update of STAR status and information from field studies (Ueli Angst or other WG member): 15'*

**WG6:** *Carbonation of alkali activated concrete (Gregor Gluth, Xinyuan Ke)*

- *Status of activities – carbonation of concrete with high volume of SCMs (Gregor Gluth): 20'*

*Future activities and meetings:*

- *7th meeting: RILEM Spring Convention 2021 Paris, France, \*75 years celebration\*, Tuesday 6th April 2021 to Friday 9th April 2021*

*Miscellaneous:*

- *Reminder: Request of TAC to review the RILEM recommendation CPC18: measurement of hardened concrete carbonation depth: Revision to be made after the ILT*
- *Request by the RIM to share on the RILEM bits & bobs newsletter any news, outcomes or events related to the Technical Committee (text no longer than 100 words and a picture in high resolution).*

*Closure*

## Minutes

**Attendees (44):** A. Marsh, A. Antonova, A. Varzina, B. Huet, B. Lothenbach, B. Walkley, B. Wu, C. Andrade, C. Le Galliard, C. Medina, C. Thiel, C. Zhang, D. Ashish, E. Gruyaert, F. Martirena, F. Moro, G. Gluth, G. Ye, H. Vanoutrive, I. Ignjatovic, I. Garcia, J. Sanchez, K. Sideris, L. Valentini, M. Etxeberria, M. Geiker, N. Alderete, N. De Belie, P. Quoc Tri, P. Van den Heede, R. Snellings, S.A. Bernal, S. Kamali Bernard, S. Keßler, S. von Greve-Dierfeld, T-C Ling, U. Angst, V. Talakokula, X. Shi, X. Ke, Y. Dhandapani, Y. Villagran, Z. Liu, Z. Zhao,

**Apologies (3):** P.A.M. Basheer, L. Black and J. Provis

*13:30 – The chair of the TC, N. De Belie, welcomes everyone and checks the list of participants attending the TC (the final list of participants has been subtracted from the Zoom list).*

An update on membership of the TC / new members was provided and the minutes of meeting 5, Guimaraes, 09/03/2020 were approved.

It was indicated that all WG met previously to the general TC meeting to discuss details about progress made regarding proposed activities. In this meeting WG leaders will kindly present and overview of the outcomes of those meetings for information of all the TC members.

*13:45 - WG4: Effects of combined actions: load + carbonation (Ling Wang, Juan Li, Yao Yan)*

- *Status of the development of the loading devices and first round of the inter-laboratory comparison (Juan Li). Minutes of the WG pre-meeting and presentation available in the RILEM TC website*

**13:55 - WG1 and WG2:** *Correlation between atmospheric carbonation and carbonation induced by accelerated testing at high CO<sub>2</sub> concentrations (Barbara Lothenbach, Elke Gruyaert, Philip Van den Heede) / Effect of SCMs on natural and accelerated carbonation of blended Portland cements (Stefanie von Greve-Dierfeld, Leon Black)*

- *Status of the State-of-the-art paper: RILEM TC 281 – Understanding the Carbonation of Concretes with Supplementary Cementitious Materials (Stefanie von Greve-Dierfeld) – [Presentation available in RILEM TC website](#)*

An overview about the timeline, and content of the paper was shared with all TC members. Very positive reviewer comments have been received and it is expected that the paper will be submitted, after revisions, by the end of September 2020.

- *Status of the paper: Critical review of existing standardised test methods to determine carbonation resistance of concrete with supplementary cementitious materials (Susan Bernal) – [Presentation available in RILEM TC website](#)*

A call for revision of the standards list was made, to make sure all the information is available while analysing these testing methodologies.

It was suggested that once this paper is ready, in combination with the outputs of the ILT, the TC will be in a strong position to make a revision of the RILEM recommendation on carbonation testing.

- *Status of the inter-laboratory test: first results, delays and adjusted timing, planning (Elke Gruyaert) – [Presentation available in RILEM TC website](#)*

Overall the ILT is going well, and sufficient data have been collected over the past months for a detailed analysis of the outcomes.

It was discussed that there might be opportunity to do additional tests on samples produced for the ILT, so that further information such as gas diffusivity and/or moisture content (water penetration profiles) of fully carbonated specimens can be determined. These results will be of great value to analyse corrosion potential of steel rebars embedded in the tested concretes. This will aid to clarify the conditions in the SCI.

N. De Belie suggested that in those laboratories where samples need to be removed from the carbonation/ curing chamber, it is recommended to seal store them to avoid further carbonation and keep the samples as intact as possible. These samples can be potentially be made available to other TC members for future analysis.

Further discussions about practical considerations to perform gas diffusivity tests in samples from different laboratories took place in the Zoom's chat, where B. Huet provided information regarding sample cutting/ extraction, sample dimensions etc (see chat conversation at the end of the document).

It was decided that WG1&WG2 leaders will send an email to all TC members about opportunities to conduct additional tests to those agreed for the ILT.

**14:50 - WG3: Modelling of carbonation (Bruno Huet, Christoph Gehlen)**

- *Status of activities of WG3 and future plans (Bruno Huet).*

A questioner designed to gather information about different carbonation modelling approaches, including data inputs and potential outputs generated from those models was distributed to all WG members. After some feedback, this document was simplified considering two material properties (e.g. physical properties, based on permeability properties, and chemistry, considering phase assemblages and precursors compositions).

Discussion has been carried out regarding preparation of an overview paper on carbonation modelling, where the outcomes of the questioner will be included, and an outline of such paper was shared and discussed during the TC meeting (**proposed paper outline and content is available in the TC folder**).

**WG5: Effect of carbonation on corrosion of concrete with SCMs (Ueli Angst, Fabrizio Moro)**

- *Update of STAR status and information from field studies (Ueli Angst). Pre-recorded overview was presented (this document is available in the RILEM TC folder)*

A pre-recorded presentation (**available in the TC folder in the RILEM website**) was shared with all TC members, which concluded from the literature review and inspection of structures in Japan and Finland, that carbonation will not have a significant impact on the corrosion of steel, and a paradigm shift needs to be proposed to drive future efforts towards hindering water movement (moisture gradients within the material, particularly at the SCI) and cover layer characteristics. It needs to be clarified that this is mentioned from the perspective of corrosion alone, as carbonation can have a negative impact in the mechanical performance of concretes with SCMs.

B. Huet asked how best we can characterize materials, so that the results we obtain can be used as potential inputs for better understanding the effects of carbonation in the SCI. U. Angst mentioned that, from the perspective of corrosion, the most important aspect is the pore structure of the final material once carbonation happens, and carbonation rates as this is linked to the moisture gradients within the concrete cover layer. Other aspects to take into consideration are the chemistry of liquid phase in the SCI, which seems not to have a dominant effect in the corrosion mechanism, but it might influence corrosion rates.

**WG6: Carbonation of alkali activated concrete (Gregor Gluth, Xinyuan Ke)**

- *Status of activities – carbonation of concrete with high volume of SCMs (Gregor Gluth):*  
**20'**

This WG has been conducting a meta-analysis of data available in the literature, as well as unpublished data contributed by TC members to evaluate carbonation performance of alkali-activated concretes. Data for natural and accelerated carbonation results were analysed as a function of the carbonation coefficient (calculated using the Fick's law relationship) vs

different parameters such as  $w/CaO$  or  $w/(CaO+MgO)$  or  $w/(CaO+Na_2O)$ , as this is the typical approach followed for Portland cement type concretes. Results revealed that there is no correlation between the carbonation coefficients determined for these materials, neither under natural, nor under accelerated conditions, with the selected parameters of comparison.

S. Bernal pointed out that it has been proposed that in these materials carbonation is a chemically controlled mechanism rather than a diffusion controlled mechanism and perhaps it will be best to use other approaches to represent the progression of carbonation. It was suggested to look into chemical reaction type models previously published by S. Bernal and M. Castellote, as a potential approach to fit the data collected.

It was also pointed out that the readings when using a pH indicator, are not truly representative of the decarbonisation of the Ca-rich phases present in this materials, but instead it seems that it provides an indication between the oxygen permeating in the samples (it is often observed that the phenolphthalein colour change matches the decolouration boundary of tested samples), and potentially carbonation of Na-rich pore solution.

C. Andrade pointed out that the theoretical correlation between natural and accelerated carbonation only works for CEM I based materials, and can only be applied if we are comparing exactly the same material, with the same degree of reaction, but exposed in different environments.

#### Future activities and meetings:

- 7th meeting: RILEM Spring Convention 2021 Paris, France, \*75 years celebration\*

It was mentioned that COVID restrictions might not be lifted by the time of this event, so it is uncertain if an in-person TC meeting could take place. It was suggested to keep these days in the agenda and have a TC meeting in person or virtually.

It was suggested to WG leaders to continue schedule meetings between now and the next TC meeting next year to continue making progress on their activities. It is kindly requested to all WG leaders to prepare minutes during those meetings, and share them with N De Belie and S. Bernal, so records can be kept in the TC folder in the RILEM website.

#### Miscellaneous:

- Reminder: Request of TAC to review the RILEM recommendation CPC18: measurement of hardened concrete carbonation depth: Revision to be made after the ILT

It was commented that the TC will be in a better position to make this revision, and propose a new recommendation once the 2<sup>nd</sup> paper and ILT results are processed and available.

- Request by the RIM to share on the RILEM bits & bobs newsletter any news, outcomes or events related to the Technical Committee (text no longer than 100 words and a picture in high resolution).

It was recommended to advertise the publications coming from the TC in bits&bob. Leading co-authors of the papers need to contact Daniela in the General RILEM office to publicise these publications.

Invitation to publish outcomes of the WG activities in the RILEM technical letters was also made.

16:00 Closure

## Appendix – Zoom chat discussion

Zoom Group Chat

From Charlotte Thiel to Everyone:  
@Bruno: One of my idea was to leave some samples in the chambers until they are fully carbonated and the do the gas diffusivity test. How do you typical do it? On carbonated or non-carbonated samples?

From Philip Van den Heede to Everyone:  
I was having the very same idea, Charlotte. Also very interested in testing the gas diffusivity of the fully carbonated state.

From Charlotte Thiel to Everyone:  
I am just not sure how long it takes until they are fully carbonated - so me I'll have to cut them and measure slices.

From Mette Geiker to Everyone:  
Thank you for the update; unfortunately I have to leave for another meeting. Best regards, Mette

From Phung Quoc Tri to Everyone:  
Problem is that you have to carbonate the sample with the size that is suitable to put into the diffusion cell. This is typically in cylindrical shape. We are now casting samples as prism!

From Charlotte Thiel to Everyone:  
we can drill cylinders out of the prisms

From Philip Van den Heede to Everyone:  
yes, for the concrete that should be possible. Those prisms are quite large for the mortar prisms it might be tricky

From Phung Quoc Tri to Everyone:  
Right, Philip

From Charlotte Thiel to Everyone:  
for mortar the diameter we use is 35 mm which is exactly the diameter of Mounas cell for cement paste and mortar

From Philip Van den Heede to Everyone:  
ok, than mortar should work as well

From Phung Quoc Tri to Everyone:  
ok, then it may work, but in our Institute, we use bigger cell of 100mm in diameter

From Charlotte Thiel to Everyone:  
What do you think about placing the drilled cylinders in resin to get the desired diameter and then compare our results?

From Phung Quoc Tri to Everyone:  
it may work again! But from my experience, we should limit the thickness of resin to prevent any difference in shrinkage/swelling of cement/concrete and resin

From Philip Van den Heede to Everyone: 03:07 PM  
If it would work that would be great. If not, we could decide to test the concrete in the cell available at SCK, and then the mortar in Mouna's cell

From Bruno HUET to Everyone: 03:09 PM  
WE have two type of cells 40 and 100 mm in diameter  
we could core and cut samples our of the samples used for carbonation...and characterize both the carbonation zone and the uncarbonated core so maybe no need to fully carbonate

From Phung Quoc Tri to Everyone:  
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From Bruno HUET to Everyone:  
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we could core and cut samples our of the samples used for carbonation...and characterize both the carbonation zone and the uncarbonated core so maybe no need to fully carbonate difficult to follow the written discusion....sorry

From Phung Quoc Tri to Everyone:  
You still need fully carbonated materials for diffusion test, right?

From Charlotte Thiel to Everyone:  
@Bruno: That would be great!

From stefanie von Greve-Dierfeld to Everyone:  
Could you tell me the diameter and height of the cores you need for the Oxygen diffusion test?

From Bruno HUET to Everyone:  
if carbonation depth are sufficient 5 to 20 mm it is oK

From Charlotte Thiel to Everyone:  
@Philip: Yes, but you can vary the thickness in the cells at Lafarge

From Bruno HUET to Everyone:  
yes we can test any thickness (almost): mortar cell

From Philip Van den Heede to Everyone:  
ok, then indeed fully carbonated state seems not needed. That would save us a lot of waiting time

From Bruno HUET to Everyone:  
40 mm in diameter, 21to 20 mm in thickness  
concrete cell 100 mm in diameter, we have test thickness from 2 mm to 50 mm  
sorry

From Siham Kamali Bernard to Everyone:  
Hello Bruno, I guess that you cut the samples without using water, what about temperature?

From Bruno HUET to Everyone:  
40 mm in diameter 2 to 20 mm in thickness usually wet yes... for cutting with discs

From Charlotte Thiel to Everyone:  
we also cut and drill wet

From Siham Kamali Bernard to Everyone: 03:18 PM  
Do you use specific discs, we use diamond disc sbut we remark a significant increase of temperature ...

From Bruno HUET to Everyone: 03:19 PM  
we use discs from standard supliier  
I ll ask colleagues wether they noted temperature increase

From Phung Quoc Tri to Everyone: 03:20 PM  
With water, we do not see Tem increase

From Siham Kamali Bernard to Everyone: 03:21 PM  
Thanks Bruno. with water, we change the RH of the material

From Bruno HUET to Everyone: 03:21 PM  
we will resaturate the samples anyway to measure the gas diffusivity down the RH scale

From Phung Quoc Tri to Everyone: 03:21 PM  
the samples indeed need to be pre-conditioned before diffusion test

From Guang Ye to Everyone: 03:22 PM  
@ Bruno, in the modelling of carbonation, do you also include alkali-activated materials?

From Bruno HUET to Everyone: 03:25 PM  
@Ye ..... in the application section yes...but I do not know specifi model to AAM....but I would really like looking into this... do you have input

From Phung Quoc Tri to Everyone: 03:25 PM  
I think no AAMs is included for now Guang Ye

From Fernando Martirena to Everyone:  
Thanks Ueli for the nice presentation!

From Guang Ye to Everyone:  
@Bruna, we are working on modelling of Cl-transport in AAC

From Xinyuan Ke to Everyone:  
Hi @Bruno @Guang Ye, if you are thinking about including AAM in the modelling, I would like to contribute to the thermodynamic part for the chemical reactions. We've recently published a paper on the thermodynamic modelling of the carbonation of alkali-activated slag. Thanks