

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

Meeting 4, Tuesday 17 September 2019, 13.30-18.00
Club D at the Prague Congress Centre, Prague, Czech Republic

Minutes

In attendance:

TC members (26): C. Andrade, N. de Belie, S.A. Bernal, Ö. Cizer, M. Etxeberria, G. Gluth, C. Grengg, Y. Guang, B. Huet, I. Ignjatović, S. Kamali-Bernard, I. Li, A. Marsh, C. Medina Martinez, J.L. Provis, P. Quo-Tri, Z. Shi, C. Thiel, M. Thomas, P. Van den Heede, A. Vollpracht, Stefanie von Greve-Dierfeld, B. Walkley, L. Wang, M. Zajac, Z. Zhao

Guests (3): R. Sposito, Z. Wang, Y. Cao

Apologies (22): A. Camoes, P. Dangla, V. Ducman, J. Elsen, C. Gehlen, E. Gruyaert, K-I. Imamoto, A. Kanellopoulos, X. Ke, S. Kessler, Q.-F. Liu, I. Martins, K. Olonade, R. Patel, J. Perko, K. Sideris, L. Valentini, H. Vanoutrive, Y. Villagran, T. Visalakshi, Y. Yao, S. Zhutovsky

Agenda

13.30 Welcome and short introduction of participants

Update on membership of the TC / new members.

13.40 Approval of the minutes of meeting 3, Rovinj, 19/03/2019

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

WG1: *Correlation between atmospheric carbonation and carbonation induced by accelerated testing at high CO₂ concentrations (Barbara Lothenbach, Elke Gruyaert, Philip Van den Heede)*

WG2: *Effect of SCMs on natural and accelerated carbonation of blended Portland cements (Karen Scrivener, Leon Black, Stefanie van Greve-Dierfeld)*

- Stefanie von Greve-Dierfeld: *Status of the State-of-the-art paper (status of the revision, internal review process, next steps and deadlines, ...)*
- Barbara Lothenbach / Philip Van den Heede: *Status of the inter-laboratory test planning: protocols, grouping of labs with same protocol, mix designs, timing, ...*

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

- Gregor Gluth: *status of activities – carbonation of concrete with high volume of SCMs*

Coffee break

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

- Bruno Huet: *status of activities of WG3 and future plans*

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

- Juan Li: *status of the annotated bibliography, discussion on loading device setup, proposal for inter-laboratory comparison*

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

- *Carmen Andrade update of STAR status and information from field studies*

17.30 Future activities and meetings

- *5th meeting: RILEM Spring Convention 2020 Guimarães, Portugal, 10-14 March 2020*
- *6th meeting + workshop (conference session): August 2020, Sheffield (UK), 74th RILEM Week, 30/08 to 4/09/2020*
- *7th meeting: RILEM Spring Convention 2021 Paris, France, *75 years celebration**

Reminder of procedures: try to limit mail traffic!

- *Mailing list: rilemtc-ccc@lists.ugent.be to be used by TC and WG chairs*
- *Doodles to confirm participation / apologize for meetings*

18.00 Closure

[17th September – Meeting opened at 13.35](#)

13.35 Welcome from TC Chair N. de Belie to new members and approval of minutes from Rovinj meeting

13:40 WG1 presented status of state-of-the-art review

- The timeline for final revision of the state-of-the-art review was shared with TC members (details in WG1 slides)
- Overview of the content of the state-of-the-art paper and further actions outlined
- N. de Belie and B. Lothenbach will do a review of the paper by 15th November 2019. Within the pending actions it was mentioned that figures copyrights need to be requested.

13:55 Interlaboratory test (ILT) on carbonation methods

- Overview of the scope of WG1 and WG2 was presented, and the motivation to perform the interlaboratory experiments was discussed (differences in exposure conditions recommended by different standards)
- The objective of the interlaboratory was stated – compare different national and EU standards to learn about the effect of curing and pre-conditioning of samples, accelerated testing conditions, as well as effect of coarse aggregates in the carbonation performance of mortars/ concretes with SCMs. Furthermore, it is aimed to compare the ranking of binder types
- Reference curing, pre-conditioning will be used to evaluate reproducibility of results across all laboratories was indicated.
- Clarification about the types of binders that will be produced, and the curing and pre-conditioning conditions to be adopted during testing was clarified.
- Overview of the testing standards and conditions used for all 25 laboratories volunteering to participate in the interlaboratory test was shown.
- Coordination of grouping labs for testing carbonation (for mortars a total of 5 groups were identified) was carried out considering CO₂ concentration used during accelerated carbonation testing, following the different standards available.
- Reduced number of participants doing concrete

- Natural carbonation - three main groups for mortars and concretes (indoor and outdoor)
- One of the questions raised about pre-defined curing was addressed – particularly looking at standard curing - If the pre-conditioning recommended in a given accelerated standard is different to the ‘standard curing’ recommended for a given type of binder, it was suggested that two different sets of samples need to be produced, to account differences in degree of hydration.
- Timeline regarding the interlaboratory programme was shared. A brief overview is given here, but full details are available in the ILT slides:
 - Oct 2019 delivery from suppliers
 - Autumn 2019 start production of samples,
 - First results to be reported by 29th Feb 2020 to be discussed in the meeting in Portugal.
 - It is expected that by June 2020 we will have the reporting of the outcomes.
 - January 2021 we will have an intermediate report on natural carbonation
 - End 2021 final report natural carbonation results
- Instructions regarding testing of samples was discussed. Discussion was mainly centered on defining ‘standardized testing conditions’ to be followed by all labs, in addition to the conditions specified by each of the accelerated carbonation tests to use.
- For concrete specimens, each lab needs to work with their own aggregates (characteristics should be documented) and a naphthalene based superplasticizer needs to be used. Pre-conditioning of aggregates was also mentioned.
- Discussion about open points in the instructions
 - For concretes water/cement - 0.50 was suggested for robustness purposes aiming to reduce potential impact in variability of gradation of aggregates (adapt to slump class S3-mixture according to EN standards); but final decision will follow later and will be included in the ILT guidelines
 - For mortars it was also suggested water/ cement – 0.50 and sand:cement:water ratios were also given; but final decision will follow later and will be included in the ILT guidelines
 - Some tips for achieving the slump class and avoid segregation were presented
 - Mortars consistency, air content and bending and compressive strength at 28 days should be measured according to EN 196-1, collecting data at different ages of curing will be valuable. Ages of curing to be defined
 - For natural testing according to EN 12390 starting date for initiating the test was also proposed for all different types of binder
 - Demoulding, curing and pre-conditioning was suggested as well as exposure conditions that need to be monitored daily for the duration of the test.
 - Specify the indicator conditions to be used (70% alcoholic solution of phenolphthalein, and make readings after 10 min of spraying). It was suggested to test other indicators – Charlotte Thiel (TUM) will provide more information about these specifications

- It was highlighted the need to select a standardized testing method to produce mortars and to evaluate them. As the majority of laboratories participating in this activity are based in Europe, it was suggested to follow the EN standards. Numbers of standards will be provided for the different tests.
 - Mixing needs to be done following a general procedure to minimize variability.
 - For concretes testing - a strength class 42.5 was suggested by Heidelberg cement. It needs to be revised what strength classes are required for each of the different types of blended cements to be evaluated in the ILT.
 - It was suggested that it will be better to specify cement of the same strength class (52.5), this will mean that natural carbonation will be visible during the life of the TC.
 - Amount of cement in concrete was discussed - 340 kg/ m³ cement in concrete mixes will allow to produce a more robust material but natural carbonation might not be detected during the ILT.
 - Discussions about when to start natural carbonation testing also took place, this decision needs to consider seasons in different regions?
- After the meeting it was decided to go for the same strength class (42.5N) for the different cements, even if cements will then come from a different factory. In the meantime (18/10/2019) the cements have been ordered by Barbara: 2000 kg of CEM I 42.5 N and CEM II/B-V 42.5 N and 1000 kg for CEM III/B 42.5 N.

14:55 WG6 overview – carbonation of alkali-activated materials

- Approach of the WG is defined – analyse published carbonation data in mortar and concretes to identify relationships between materials performance, mix designs and carbonation conditions adopted.
- Papers on CEMIII-B and CEMIII-C are also considered in this overview
- The number of papers identified was mentioned as well as data sent by TC members
- Correlation between carbonation rate vs w/CaO ratio shows very similar carbonation rates between alkali-activated concretes and CEMIII-B and CEMIII-C
- It was mentioned that the rate of carbonation needs to be presented in mm/ year to be consistent with other publications in the field
- Work in progress was also mentioned (e.g. identify MgO content of GGBFS)
- A draft paper will be circulated in January 2020.

15:15 WG3 overview of activities in modelling on carbonation

- Members of this WG met in the days before to this meeting, and minutes are available in the TC folder.
- In general the minutes of this WG provide an overview about its vision, including evaluation of capacity to model real climate (based on *fib* model – weather function)
- The WG will prepare a couple of papers on different types of modelling, and propose a benchmark modelling approach and highlight models needs

- The WG is currently creating a database of existing carbonation models (google drive file was circulated to TC members)
- A survey of models was also created. At present the survey limited to WG members to collect information about any kind of model for predicting carbonation of concrete, mainly for statistical purposes and to understand the motivations for following the described modelling approaches
- Efforts need to be coordinated with *fib* to take into account engineering models that have been developed/ revised/ extended at present. It was suggested to discuss about this with Christoph Gehlen, TUM.

16:10 – WG4 update on activities related to combined effect of loading-carbonation

- Scope, objectives and expected outcomes of WG4 were outlined
- An annotated bibliography on gas permeability and loading is currently in preparation, and an outline of this state of the art report is ready, and circulated to WG members for comments.
- A set up for evaluating effect of loading on carbonation provided by Belgrade University was discussed based on four-points bending test
- Overview of activities conducted in RILEM TC 246-TDC was presented
- Challenges with different experimental set ups was discussed
- 4 laboratories have volunteered to join interlaboratory test
- Interlaboratory specifications were mentioned and need to be revised based on EU standards (CO₂ concentrations values are natural, 2 and 20%)
- Ghent U. presented the prototype they have developed to perform carbonation loading experiments and some validation results for the proposed set up
- Detailed minutes of the meeting of this WG4 are available in the TC folder

16:50 WG5 overview of activities in corrosion of concretes with SCMs

- Discussions among WG members inspired the preparation of a white paper on corrosion, and the questions that need to be answer considering the available data in the literature. This with the aim to identify research needs in the area of corrosion induced by carbonation.
- There is little understanding of the mechanism of de-passivation caused for carbonation.
- Overview of studies conducted by Carmen Andrade on carbonation-chloride effect on corrosion of steel

17:20 General remarks

- 1st meeting in 2020 will take place during RILEM Spring Convention – Portugal (<https://www.rsc2020.civil.uminho.pt/>) the specific day to be defined
- 2nd meeting in 2020 will take place during RILEM Week – UK. It has been agreed with organisers to have a dedicated session for this TC. When submitting abstracts to the event, it needs to be specified that the talks are linked to this session.

- RILEM is currently revising all its existing recommendations, including CPC- 18 (<https://link.springer.com/article/10.1007%2FBF02472327>) measurement of hardened concrete carbonation depth. All TC members are invited to provide comments/ feedback about this recommendation.