

## Minutes of the 4<sup>th</sup> meeting of RILEM TC-CCC WG4

<b>Time</b>	9:00-11:00, Tuesday, 23 March 2021 (UTC+2) [16:00-18:00, Beijing Time]
<b>Venue</b>	Microsoft Teams Online Meeting Room
<b>Main Subjects</b>	<ol style="list-style-type: none"><li>1. Discussion on the test results of the 1<sup>st</sup> &amp; 2<sup>nd</sup> test series of 6 labs</li><li>2. Possible modifications of the test program</li><li>3. Discussion on a detailed plan of the 2<sup>nd</sup> test series</li></ol>
<b>Participants</b>	Altogether 21 participants attended the meeting: ADU-AMANKWAH Samuel, BANSAL Tusher, BASHEER Muhammed, DE BELIE Nele, DHANDAPANI Yuvaraj, HUANG Yu, KAMALI-BERNARD Siham, KANELLOPOULOS Antonis, LI Bin, LI Juan, LIU Zhiyuan, OLONADE Kolawole, PIOLET Elodie, SHI Xinyu, SUN Tao, TALAKOKULA Visalakshi, VAN DEN HEEDE Philip, WANG Jianwei, WANG Ling, WANG Zhendi, ZHANG Cheng (Detailed information is in the annex)
<b>Moderator</b>	SHI Xinyu

At the beginning of the meeting, Prof. Ling WANG, the co-chair of RILEM TC 281 WG4, warmly welcomed all the participants and made an opening speech on behalf of the chair of WG4, Prof. Yan YAO. After all the participants' self-introduction. The secretary of WG4, Mr Xinyu SHI from CBMA, introduced the meeting agenda and the minutes of the 3<sup>rd</sup> WG4 meeting. Prof. Juan LI briefly reviewed the results of the 1<sup>st</sup> round comparative test and presented the progress of the 2<sup>nd</sup> test series in all laboratories. Six laboratories involved in the comparative test provided additional details. After a detailed discussion on the recent progress and the next steps of RILEM TC-281 CCC WG4, the following agreements were reached.

### 1. The progress of the comparative tests

Mr Cheng ZHANG from CBMA, Mr Zhiyuan LIU from Magnel Laboratory of Ghent University, Prof. Visalakshi TALAKOKULA from Bennett University, Dr. Chuansheng XIONG from the Qingdao University of Technology (represented by Mr Xinyu SHI), and Mr Yu HUANG from Yantai University introduced their work progresses respectively. For the 1<sup>st</sup> round of test, UGent, CBMA, Bennett University, and Qingdao University of Technology have finished their experiments, and Yantai University will get their test results on 25 March. The 2<sup>nd</sup> round of test in all labs will be finished

by the end of August 2021.

Dr. Elodie PIOLET from INSA – RENNES later introduced their interesting test results of 2 mortar samples under the coupling effect of flexure load + carbonation. Many suggestions were proposed for further studies, like putting the specimen upside-down, increasing the carbonation period, decreasing the w/c ratio, finer aggregates, etc. Members are looking forward to seeing her follow-up progress in the next WG meeting.

## **2. The direction of specimen placement**

Participants noticed that the test results of QUT in the 1<sup>st</sup> round of comparative tests are different from other laboratories. The carbonation depth of QUT of horizontally placed specimens is in a positive relationship with the compressive stress ratio. Participants proposed various assumptions to explain the results in QUT:

Dr. Chuansheng XIONG from QUT thought the eccentric loading, caused by the combining action of the dead weight and compression, forms tension area and compression area on the prismatic specimen. QUT's carbonation depths were obtained by measuring the carbonation depth in the bottom surface where the stress causes a tensile zone and accelerates the carbonation process. Prof. Zhendi WANG thought that such an effect depends on the size and weight of the specimen. In this case, the layout may not cause such a big difference. Dr. Philip suggested calculating the dead weight and compressive stress will reveal that horizontal placement has little effect on the stress state of concrete. Another method to evaluate the horizontal placement's influence is to find whether there is a difference between the tensile side and the compressive side. In his opinion, the lack of load monitoring may be the reason, and we shall not change the prescribed procedure before the overall comparison is conducted. Dr. Samuel mentioned that the top-loading is very important based on their creep experiment. For the case of QUT, the eccentric is not supposed to have such a big impact. The bolt & spring system may relax the load easily in a few hours, even extra pre-loaded, and load monitoring is very important for a unified applied load.

WG4 members suggested QUT and Yantai Univ. conduct comparison experiments of horizontal placement and vertical placement to verify the effect of placement direction on the

carbonation results. WG4 members also reminded the two universities to strictly control the other test conditions following the WG4 test plan, like load monitoring, during the comparison test. The comparison test results and corresponding analysis will be considered as part of the final report of WG4. Nevertheless, the vertical specimen placement was still suggested to be the only procedure in the recommendation of WG4.

### **3. The time interval before measuring carbonation depth**

CBMA has conducted experiments to investigate the influence of the time interval between spraying the indicator and measuring the carbonation depth, which indicates that the time interval of 1 hour and 30 seconds has no evident effect. Participants agreed with the results and analysis at CBMA. However, the future recommendation proposed by WG4 needs a reference document for a unified measurement procedure for carbonation depth. EN 12390-10:2018 is a better choice, so the test program for the 2<sup>nd</sup> round experiments shall be under the time interval of 1 hour as the EN standard.

### **4. The curing procedure**

The prescribed curing procedure is 1 day in moulds, 6 days in saturated  $\text{Ca(OH)}_2$  and 84 days in a chamber with 65% RH and 20°C. Some members were afraid that the concrete specimen with 30% fly ash or 50% blast furnace slag could not be adequately curing under low relative humidity like 65% RH and then no enough  $\text{Ca(OH)}_2$  for carbonation. Therefore, an optional curing procedure was proposed, that is, 1 day in moulds, 69 days in saturated  $\text{Ca(OH)}_2$  and 21 days in the chamber.

Dr. Philip thought this WG's main aim is to study the effect of load + carbonation on different concrete compositions. For the convenient comparison with the 1<sup>st</sup> round test, and the fact that many concrete samples have been prepared, there is no need to change the curing procedure. Prof. Nele thought curing aims to make a more realistic scenario for the concrete with SCMs. For fly ash concrete, the pozzolanic reaction is already started after 2~3 weeks. A 91 days curing is sufficient, and it is what is often proposed from other papers or standards. Prof. Visalakshi also agreed with the original procedure for that 90 days curing for SCMs concrete is enough to get compensation stress. Therefore, the following experiments will preserve the curing procedure of

(1+6+84) days as prescribed.

Besides, CBMA volunteered to conduct a comparison test to investigate the influence of curing procedures on the strength and hydration products of OPC concrete, fly ash concrete, and furnace slag concrete. Two curing procedures will be considered, one is 1 day in moulds, 6 days in saturated Ca(OH)<sub>2</sub> and 84 days in a chamber with 65% RH and 20°C, and the other is 1 day in moulds, 69 days in saturated Ca(OH)<sub>2</sub> and 21 days in the chamber. The corresponding results of the hydration product and mechanical strength will be presented in the next WG4 meeting.

### 5. New volunteers in the 2<sup>nd</sup> round test

Several participants are volunteered to conduct more experiments for a better comparison:

- ✓ Bennett University will conduct tension + carbonation tests of OPC, FA, BFS specimens under 2% CO<sub>2</sub>, according to the test protocols and rig diagram provided by CBMA.
- ✓ QUT planned to join the compressive + carbonation test of OPC under 20% CO<sub>2</sub>.
- ✓ Dr. Kolawole OLONADE from Univ. Lagos will also participate in the 2<sup>nd</sup> test series.

In addition, Chinese labs were encouraged to participate in the test of 20% CO<sub>2</sub>, for carbonation chamber in other labs is unable to set such high value. The updated task tables are shown as follows.

**Table 1. Task table for the 2<sup>nd</sup> round comparative test of Compression + Carbonation**

CO <sub>2</sub>	Mix	Stress ratio	Label	CBMA	UGent	Bennett Univ.	QUT	Yantai Univ.	Univ. Lagos
2%	OPC	0.0	OPC-0-2%	✓	✓	✓	✓	✓	
		0.3	OPC-0.3-2%	✓	✓	✓	✓		
		0.6	OPC-0.6-2%	✓	✓		✓		
	FA	0.0	FA-0-2%	✓	✓	✓	✓	✓	
		0.3	FA-0.3-2%	✓	✓	✓	✓	✓	
		0.6	FA-0.6-2%	✓	✓		✓	✓	
	BFS	0.0	BFS-0-2%	✓	✓	✓			
		0.3	BFS-0.3-2%	✓	✓	✓			
		0.6	BFS-0.6-2%	✓	✓				
20%	OPC	0.0	OPC-0-20%	✓			✓		
		0.3	OPC-0.3-20%	✓			✓		
		0.6	OPC-0.6-20%	✓			✓		
	FA	0.0	FA-0-20%	✓			✓	✓	
		0.3	FA-0.3-20%	✓			✓	✓	

		0.6	FA-0.6-20%	√			√	√	
	BFS	0.0	BFS-0-20%	√					
		0.3	BFS-0.3-20%	√					
		0.6	BFS-0.6-20%	√					

**Table 2. Task table for the 2<sup>nd</sup> round comparative test of Tension + Carbonation**

CO <sub>2</sub>	Mix	Stress ratio	Label	CBMA	UGent	Bennett Univ.	QUT	Yantai Univ.	Univ. Lagos
2%	OPC	0.0	OPC-0-2%	√		√			
		0.3	OPC-0.3-2%	√		√			
		0.6	OPC-0.6-2%	√		√			
	FA	0.0	FA-0-2%	√		√			
		0.3	FA-0.3-2%	√		√			
		0.6	FA-0.6-2%	√		√			
	BFS	0.0	BFS-0-2%	√		√			
		0.3	BFS-0.3-2%	√		√			
		0.6	BFS-0.6-2%	√		√			
20%	OPC	0.0	OPC-0-20%	√					
		0.3	OPC-0.3-20%	√					
		0.6	OPC-0.6-20%	√					
	FA	0.0	FA-0-20%	√					
		0.3	FA-0.3-20%	√					
		0.6	FA-0.6-20%	√					
	BFS	0.0	BFS-0-20%	√					
		0.3	BFS-0.3-20%	√					
		0.6	BFS-0.6-20%	√					

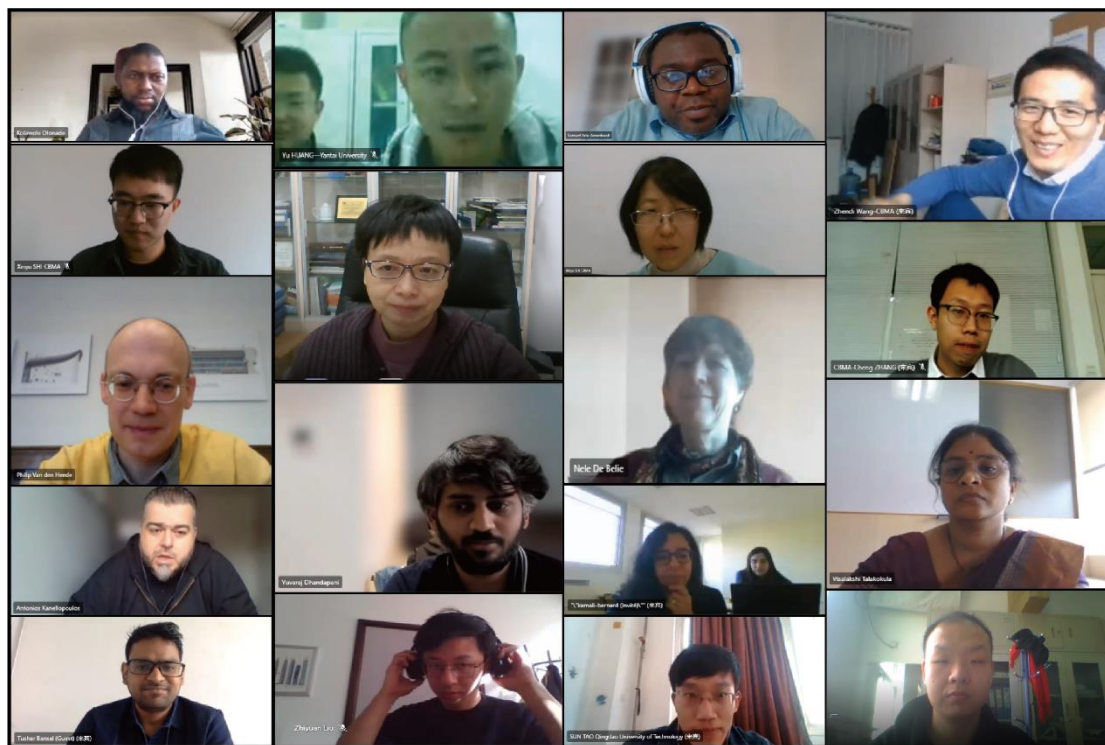
## 6. Next steps

According to the test program, the initial 5 participated laboratories will conduct and finish their own tasks by the end of August. Please send the analysis and detailed test report of the 2<sup>nd</sup> round comparative test to the secretary before October 2021. It would be the premise of our next meeting.

The new participated labs (Univ. Lagos) and labs having new additional test tasks (Bennett Univ., QUT, CBMA and Yantai Univ.) are recommended to start as soon as possible. For any needs and questions, please contact our WG4 secretary, Xinyu SHI ([shixy1994@qq.com](mailto:shixy1994@qq.com)).

The next WG4 meeting is pre-scheduled for October 2021, which will most probably still have to be online. The meeting is scheduled for half a day (about 3 h). The date for the next

meeting will be fixed after the doodle in August.



The group photo for the 4<sup>th</sup> meeting of RILEM TC 281-CCC WG4

## Annex

### Participants of the 4th WG4 meeting

NO.	Title	Name	Country	Organization	Remark
1	Prof.	DE BELIE Nele	Belgium	Ghent University	Chair of TC 281 -CCC
2	Dr.	VAN DEN HEEDE Philip	Belgium	Ghent University	
3	Mr.	LIU Zhiyuan	Belgium	Ghent University	
4	Prof.	TALAKOKULA Visalakshi	India	Bennett University	
5	Dr.	BANSAL Tusher	India	Bennett University	
6	Mr.	SUN Tao	China	Qingdao University of Technology	
7	Mr.	HUANG Yu	China	Yantai University	
8	Mr.	WANG Jianwei	China	Yantai University	
9	Prof.	KAMALI-BERNARD Siham	France	INSA - RENNES	

<b>NO.</b>	<b>Title</b>	<b>Name</b>	<b>Country</b>	<b>Organization</b>	<b>Remark</b>
10	Dr.	PIOLET Elodie	France	INSA - RENNES	
11	Prof.	BASHEER Muhammed	UK	University of Leeds	
12	Dr.	DHANDAPANI Yuvaraj	UK	University of Leeds	
13	Dr.	KANELLOPOULOS Antonis	UK	University of Hertfordshire	
14	Dr.	ADU-AMANKWAH Samuel	UK	Brunel University	
15	Dr.	OLONADE Kolawole	Nigeria	University of Lagos	
16	Prof.	WANG Ling	China	China Building Materials Academy	Co-chair of WG4
17	Prof.	LI Juan	China	China Building Materials Academy	Co-chair of WG4
18	Prof.	WANG Zhendi	China	China Building Materials Academy	
19	Mr.	SHI Xinyu	China	China Building Materials Academy	Secretary of WG4
20	Mr.	ZHANG Cheng	China	China Building Materials Academy	
21	Mr.	LI Bin	China	China Building Materials Academy	