

Réunion Internationale des Laboratoires et Experts des Matériaux

TC 281-CCC: Carbonation of concrete with SCM WG4: Effect of combined actions: load + carbonation

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Summary of the first round comparative test of WG4

China Building Materials Academy

17 Feb. 2021

Summary of the first round of comparative test

- 1. Participating labs and timetable
- 2. Concrete samples
- 3. Test rig for loading
- 4. Carbonation chamber
- 5. Results and analysis of carbonation depth

1. Participating Labs and Timetable

NO.	Leader	Lab Abbrevi		Time
1	Yan Yao	The State Key Laboratory of Green Building Materials, China Building Materials Academy, China	Key Laboratory of GreenMaterials, China BuildingcBMArials Academy, China	
2	Nele De Belie	Magnel Laboratory for Concrete, Ghent University, Belgium	UGent	17 Dec., 2020 ~ 11 Feb., 2021
3	Talakokula Visalakshi	Bennett University, India	Bennett Univ.	15 Sept., 2020 ~ 10 Nov., 2020
4	Zuquan Jin	Qingdao University of Technology, China	QUT	Jul. 2020 ~ Sept. 2020
5	Jingzhou Lu	Yantai University, China	Yantai Univ.	22 Jan., 2021 ~ 19 Mar., 2021
6	Ivan Ignjatovic	Laboratory of materials, University of Belgrade, Serbia	Belgrade Univ.	/
7	Siham Kamali- Bernard	Laboratory of Civil and Mechanical Engineering, INSA-Rennes, France	INSA	/

Note:

• A lot of samples that needed to be exposed to CO₂ were piled (from researchers and industrial partners) in the only small chamber in Ivan's lab due to several stop-and-start working periods during the 2020. He has to withdraw the 1st round comparative test.

• The INSA had really difficulties to make the same tests as prescribe, because INSA carbonation cells are quite small.

2. Concrete samples

	Cement I 42.5 /kg m ⁻³	Fine aggregate /kg m ⁻³	Coarse aggregate /kg m ⁻³	Water /kg m ⁻³	Superplasticizer /kg m ⁻³	w/c	Slump /mm
СВМА	330	719	1162	198	0.7	0.6	110
UGent	330	719	1162	198	0	0.6	220
Bennett Univ.	330	719	1162	198	1	0.6	110
QUT	330	719	1162	198	0.74	0.6	100
Yantai Univ.	330	719	1162	198	0.5	0.6	100

Mix proportion of OPC concrete

Remark:

Concrete slump from UGent is different from others. WHY?

2. Concrete samples

Curing and carbonation of concrete samples

Curing and carbonation	СВМА	UGent	Bennett Univ.	QUT	Yantai Uni.
Curing in the moulds, air temperature of (20 ± 2) °C, covering with a plastic sheet, 1 d			As prescribed	1	
In saturated Ca(OH) ₂ solution at (20 ± 2) °C, 6 d			As prescribed	l	
In climate chamber at (20 \pm 2) °C and (65 \pm 5) % RH, 21 d	As prescribed		(20±2) °C and (55±5) % RH, 21 d	(20±2) °C and 95% RH , 21	
In carbonation chamber at predefined CO ₂ 2% concentration, 20 °C and (65 \pm 5) % RH, 28 d	As prescribed		RH (55±5) %	As pro	escribed

2. Concrete samples

Compressive strength at 28 days of concrete samples

Loba	Cubes	Prisms	
Labs	/MPa	/MPa	
СВМА	38.4	34.4	
UGent	42.2	32.4	
Bennett Univ.	30.7	25.6	
QUT	43.2	36.6	
Yantai Univ.	49.4	39.3	
Mean 1	AVG: 40.8 STDEV: 6.89	AVG: 33.65 STDEV: 5.20	
Mean 2 (highest and lowest value excl.)	AVG: 41.3 STDEV: 2.53	AVG: 34.46 STDEV: 2.10	

Note:

Results of **Yantai Univ.** was the highest, and results of **Bennett Univ.** was the lowest, probably due to different RH.

Comparison of test rigs in five labs

Labs	★ Loading method	★ Stress sustaining	🛧 Load cell
СВМА		bolts and disc spring	Y
UGent		hydraulic	Y
Bennett Univ.	hydraulic press	hydraulic	Y
QUT		bolts and spring	N
Yantai Univ.		bolts and disc spring	Ν

Note: The applied load shall keep stable during the entire carbonation period. The stress applied to concrete shall be monitored in each lab (see Fig. 2).









Fig. 1 Test rigs in the five labs



(c) Bennett Univ.

(d) QUT

Fig. 1 Test rigs in the five labs





Fig. 1 Test rigs in the five labs



Fig. 2 Applied load vs. time

- When the stress drops by more than 10%, the stress compensation is needed.
- The load shall be compensated every $7 \sim 9$ days.

4. Carbonation chamber

Labs	Size of carbonation chamber (L*W*H)	Size of loading frame (L*W*H)	Direction of loading frame	Number of loading frame in chamber
СВМА	150 cm×86 cm×90 cm	20 cm×20 cm×63 cm	vertically	18
UGent			vertically	
Bennett Univ.			vertically	
QUT			horizontally	
Yantai Univ.			horizontally	

Comparison of carbonation chambers in the five labs

Note: The size of carbonation chamber shall be big enough to contain at least $9 \sim 12$ specimens with loading, and the height shall be enough for specimens being vertically placed.

Discussion: Is it acceptable to place the specimens horizontally?

4. Carbonation chamber



(a) CBMA





Fig. 3 Carbonation chambers of the five labs

4. Carbonation chamber



(c) Bennett Univ. (please add a photo with door open)



(d) QUT



(e) Yantai Univ.

Fig. 3 Carbonation chambers of the five labs



Fig. 4 Carbonation depth of concrete tested in the five labs



Fig. 4 Carbonation depth of concrete tested in the five labs

The test results of Yantai Univ. will be available on 2021/03/19.

(e) Yantai Univ.

Fig. 4 Carbonation depth of concrete tested in the five labs



Fig. 5 Comparison of the test results of different labs

Loading effect on carbonation depth:

•The applied load (stress ratio 0.45) inhibits carbonation from results of CBMA and Bennett Univ..

•Whereas the applied load (stress ratio 0.45) accelerates carbonation from results of QUT.

Specime n	Measured at 30 s after spraying the indictor / mm	Measured at 1 h after spraying the indictor / mm
1	5.14	5.33
2	5.51	5.54
3	5.48	5.53
Mean	AVG: 5.38, STDEV: 0.441	AVG: 5.47, STDEV: 0.419

Comparison of carbonation depth measured at different time (CBMA)

Note: Carbonation for 28 d at 20% CO_2

- 1 h (as prescribed in test plan of the 1st round of comparative test, and as EN 12390-10:2018)
- 30 s (Chinese Standard GB/T 50082-2009)
- No evident difference in *Dc* between 1 h and 30 s was found according to the test results of CBMA.

Thanks for the cooperation from the five labs participating in the comparative test series !

