Réunion **I**nternationale des **L**aboratoires et **E**xperts des **M**atériaux

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

Updated plan of the 2nd round comparative test of WG4

China Building Materials Academy

17 Feb., 2021

Updated plan of the 2nd round comparative test of WG4

1. Participating Labs and Timetable
2. Scope
3. Equipment
4. Mix Design
5. Preparation of Test Samples
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1. Participating Labs and Timetable

No.	Leader	Labs	Time
1	Yan Yao	CBMA	• Casting & Curing: 2020.10-2021.01 • Carbonation: 2021.01-2021.02
2	Nele De Belie	UGent	• Casting & Curing: • Carbonation:
3	Talakokula Visalakshi	Bennett Univ.	• Casting & Curing: • Carbonation:
4	Zuquan Jin	QUT	• Casting & Curing: • Carbonation:
5	Jingzhou Lu	Yantai Univ.	• Casting & Curing: • Carbonation:
6	Ivan Ignjatovic	Belgrade Univ.	• Casting & Curing: • Carbonation:

Duration for the 2nd round comparative test:

- Casting & Curing: 3 months
- Carbonation: 1 month

2. Scope

- To determine durability of concrete with SCMs （FA and/or BFS）under combined actions of carbonation and compressive / tensile load.

➢ **Carbonation + compressive load**

- Carbonation and compression simultaneously.
- The pre-defined compressive stress ratios for the second round of comparative testing are 0.30, 0.60 (0.80 optional). A comparison will be made with the unloaded condition.
- 3 specimens for each stress ratio.

➢ **Carbonation + tensile load (optional)**

- Carbonation and tension simultaneously.
- The pre-defined tensile stress ratios for this round of comparative testing are 0.30, 0.60. A comparison will be made with the unloaded condition.
- 3 specimens for each stress ratio.

3. Equipment

➢ Test rig for compression

• The test rigs were confirmed by 6 labs in the 1st round of comparison test.

• Test rigs, which have the same principle and function and fulfil the requirements of RILEM recommendation of TC 107-CSP can be used as well.

• The applied load shall keep stable during the entire carbonation period. The stress applied to concrete shall be monitored in each lab.

➢ Test rig for tension

• The test rigs designed by RILEM TC 246-TDC as shown in Fig. 1.

Materials and Structures (2017) 50:155 DOI 10.1617/s11527-017-1000-3

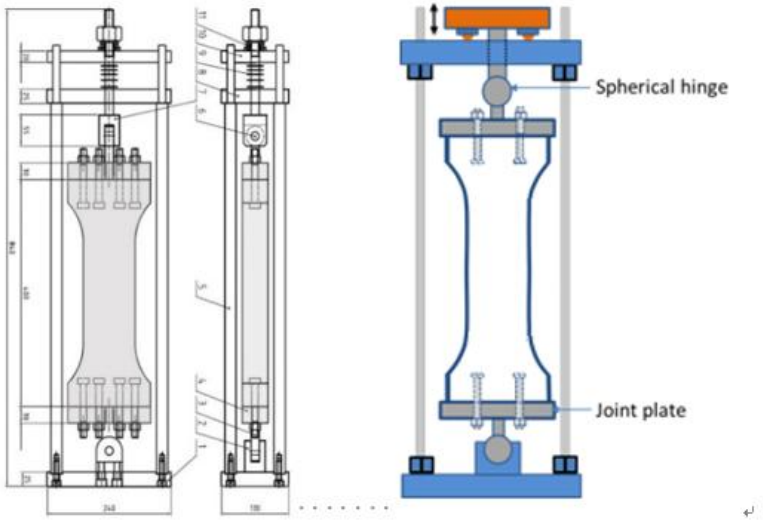


Fig. 1 Test rig for tension

3. Equipment

➢ Carbonation Chamber

- **Temperature:** (20 ± 2)℃
- **Relative humidity:** 65% ± 5%
- **CO_2 concentration:** 2% or 20%
- **Size:** The size of carbonation chamber shall be big enough to contain at least 9 ~ 12 specimens with loading, and the height shall be enough for specimens being vertically placed.

4. Mix Design

- Cement type: CEM I 42.5
- FA: 30% replacement of cement
- BFS: 50% replacement of cement
- Water reducer: Polycarboxylates superplasticizer, concrete slump controlled at (110±10) mm.

Mix proportions of concrete

No.	Cement (kg/m^3)	w/c	SCMs (kg/m^3)	Water (kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)	Superplastizer (kg/m^3)	Slump (mm)
OPC	330	0.6	0	198	719	1162	(As needed)	110
FA	231	0.6	99	198	719	1162	(As needed)	110
BFS	165	0.6	165	198	719	1162	(As needed)	110

5. Preparation of specimens

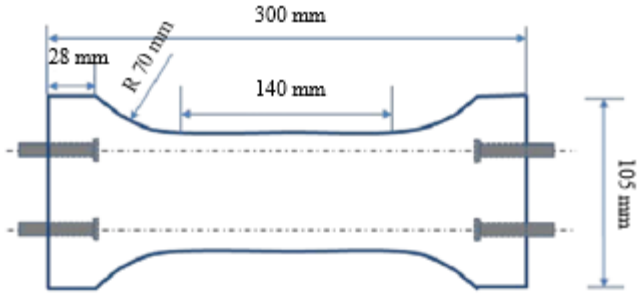
➢ Concrete specimen for (**compression** + carbonation)

- Plain concrete without reinforcement.
- Number: At least 3 cubes and 21 prisms (100×100×300 mm^3) for one series (one concrete mix).

  - Group I: 3 cubes for compressive strength test (f_{cc});
  - Group II: 3 prisms for compressive strength test (f_{cp});
  - Group III: 18 prisms for carbonation with stress ratio 0, 0.3, 0.6, (0.8), CO_2 concentration 2% and 20%. (3 stress ratios *2 CO_2 concentrations*3)

	Specimens No. (2% CO_2)	**Specimens No. (20% CO_2)**
OPC	OPC-0-2%, OPC-0.3-2%, OPC-0.6-2%	OPC-0-20%, OPC-0.3-20%, OPC-0.6-20%
FA	FA-0-2%, FA-0.3-2%, FA-0.6-2%	FA-0-20%, FA-0.3-20%, FA-0.6-20%
BFS	BFS-0-2%, BFS-0.3-2%, BFS-0.6-2%	BFS-0-2%, BFS-0.3-20%, BFS-0.6-20%

5. Preparation of specimens



➢ Concrete specimen for (**tension** + carbonation)

- Plain concrete without reinforcement.
- Number: At least 3 cubes and 21 Dumbbell-shaped samples ($70 \times 70 \times 300$ mm^3) for one series (one concrete mix).
  - Group I: 3 cubes for compressive strength test (f_{cc});
  - Group II: 3 dumbbell for tensile strength test (f_t);
  - Group III: 18 dumbbell for carbonation with stress ratio 0, 0.3, 0.6, CO_2 concentration 2% and 20%. (3 stress ratios * 2 CO_2 concentrations *3)

	Specimens No. (2% CO_2)	**Specimens No. (20% CO_2)**
OPC	OPC-0-2%-T, OPC-0.3-2%-T, OPC-0.6-2%-T	OPC-0-20%-T, OPC-0.3-20%-T, OPC-0.6-20%-T
FA	FA-0-2%-T, FA-0.3-2%-T, FA-0.6-2%-T	FA-0-20%-T, FA-0.3-20%-T, FA-0.6-20%-T
BFS	BFS-0-2%-T, BFS-0.3-2%-T, BFS-0.6-2%-T	BFS-0-2%-T, BFS-0.3-20%-T, BFS-0.6-20%-T

5. Preparation of specimens

➢ Curing and carbonation

Curing and carbonation	Group I	Group II	Group III
Test aim for each group	3 cubes for f_{cc}	3 prisms for f_{cp} 3 dumbbell samples for f_t	**18** prisms or dumbbell specimen for carbonation test with and without load
Curing in the moulds, air temperature of 20 (±2) ℃, covering with a plastic sheet. ①	1 day	1 day	1 day
In saturated $Ca(OH)_2$ solution at 20 (±2) ℃. ②	6 days	6 days	6 days
In climate chamber at 20 (±2) ℃ and 65 (±5) % RH. ③	**84** days	**84** days	**84** days
In carbonation chamber at predefined CO_2 concentration, 20 ℃ and 65 (±5) % RH.	--	--	28 days

Discussion: Is it enough to improve the compressive strength of concrete with SCMs at saturated $Ca(OH)_2$ solution curing for 6 days ? Is it acceptable for a curing method of ① **1 d,** ② **69 d, and** ③ **21 d**?

6. Confirmed plan for 2nd round test

➢ Compression + carbonation

CO_2	Mix	Stress ratio	Label	CBMA	UGent	Bennett Univ.	QUT	Yantai Univ.	More labs are welcome to join
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%	√	×		×	×	

Stress ratio 0.80 is optional.

6. Confirmed plan for 2nd round test

- **Tension + carbonation (optional)**

CO_2	Mix	Stress ratio	Label	CBMA	UGent	Bennett Univ.	QUT	Yantai Univ.	More labs are welcome to join
2%	OPC	0.0	OPC-0-2%-T	√					
		0.3	OPC-0.3-2%-T	√					
		0.6	OPC-0.6-2%-T	√					
	FA	0.0	FA-0-2%-T	√					
		0.3	FA-0.3-2%-T	√					
		0.6	FA-0.6-2%-T	√					
	BFS	0.0	BFS-0-2%-T	√					
		0.3	BFS-0.3-2%-T	√					
		0.6	BFS-0.6-2%-T	√					
20%	OPC	0.0	OPC-0-20%-T	√					
		0.3	OPC-0.3-20%-T	√					
		0.6	OPC-0.6-20%-T	√					
	FA	0.0	FA-0-20%-T	√					
		0.3	FA-0.3-20%-T	√					
		0.6	FA-0.6-20%-T	√					
	BFS	0.0	BFS-0-20%-T	√					
		0.3	BFS-0.3-20%-T	√					
		0.6	BFS-0.6-20%-T	√					

More labs are invited to join the 2nd round comparative test program. Thanks for your contributions!