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Horizon Europe Research & Innovation Programme under grant agreement No 101073547.

1st RILEM International Conference on Mineral Carbonation for Cement and Concrete

NATURAL AND ENFORCED CARBONATION OF HYDRATED CEMENT PASTE

C. Rodriguez[1,2], W.R. Leal da Silva[1], J. Soosai Alphonse[1], P. Stemmermann[2], K. Garbev[2], and G. Beuchle[2]

[1]*FLSmidth A/S*, Claudia.rodriguez@FLSmidth.com

[2]*KIT, Institute for Technical Chemistry, Karlsruhe, Germany*

CO_2Valorize: Valorization of CO2 for low carbon cement

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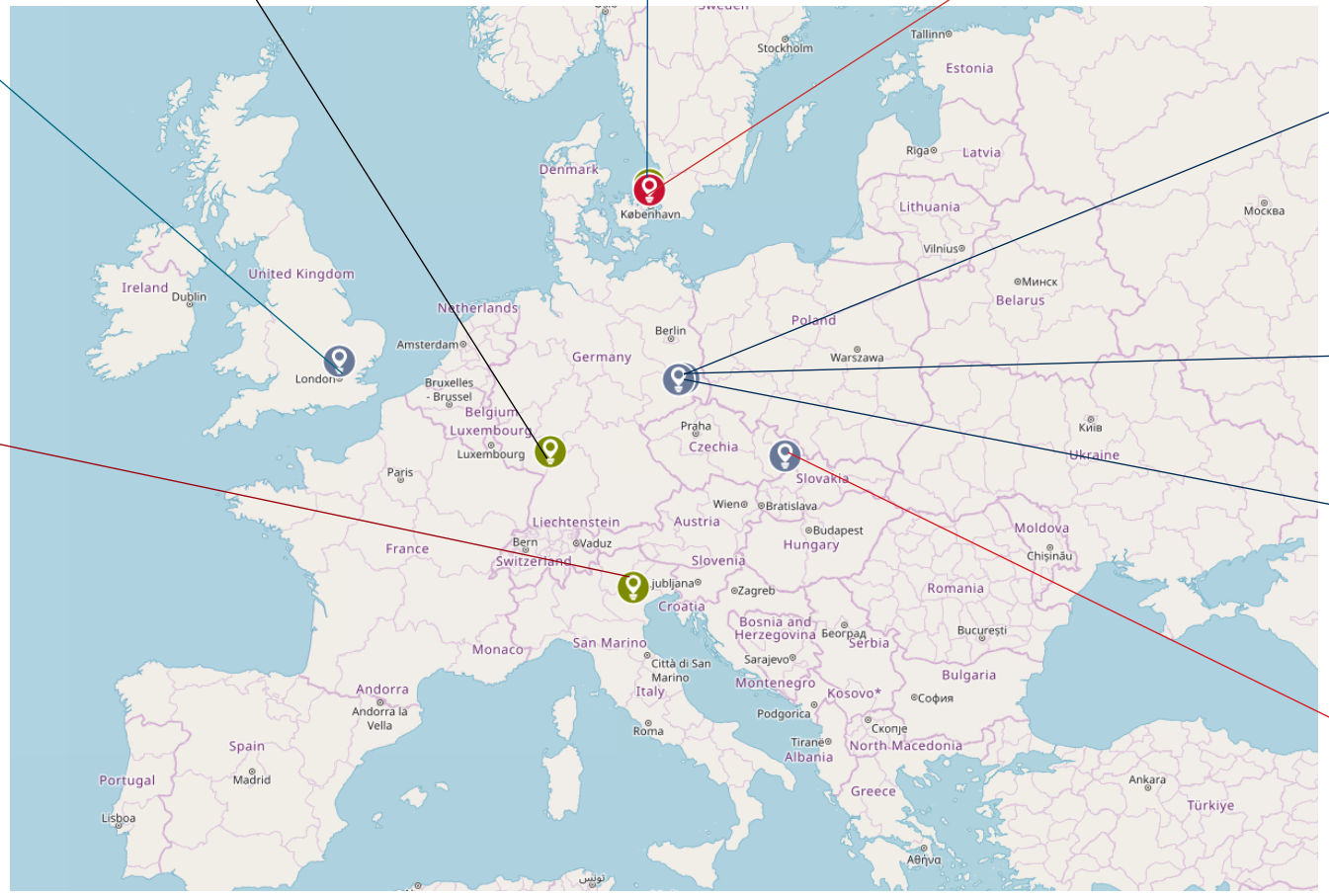
CEMMAC CEMENT



What and how to start?

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Enforced carbonation

Natural carbonation

Hydrated Cement Paste (**P**)
Recycled Concrete Fines (RCF)

What is the extension of **natural carbonation** (sourcing and experimental work)?

Does natural carbonation influence the **enforced carbonation?**

What is the **performance** of P and carbonated P as **SCMs**?

CO_2 uptake as function of:
- Controlled atmosphere (N_2 and CO_2)
- Temperature (T)
- Relative humidity (RH)
- Wet carbonation

Paste and cPaste as SCM:
- 5-10-15 wt % of SCM as cement replacement
- Compressive strength (MiniRilem)

Lab set-up

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1 Natural carbonation

Nitrogen (Glove bag)
P-N

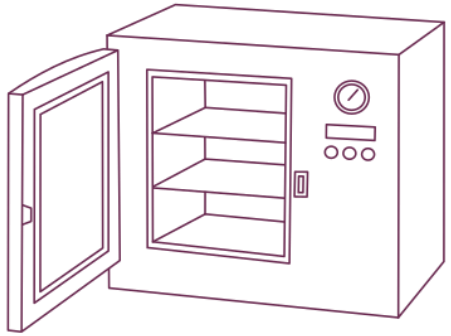
Natural carbonation

Hydrated cement paste

Environment (lab) conditions
P-E-1; P-E-14
T: 23°C. RH: 30%. CO_2: 360 ppm

Oven
P-O-1
T: 40°C. RH: 40%. CO2: 160 ppm

CEM I 52,5 N, W/b: 0,48
22-month



K_2SO_4 saturated solution to control RH

Lab set-up

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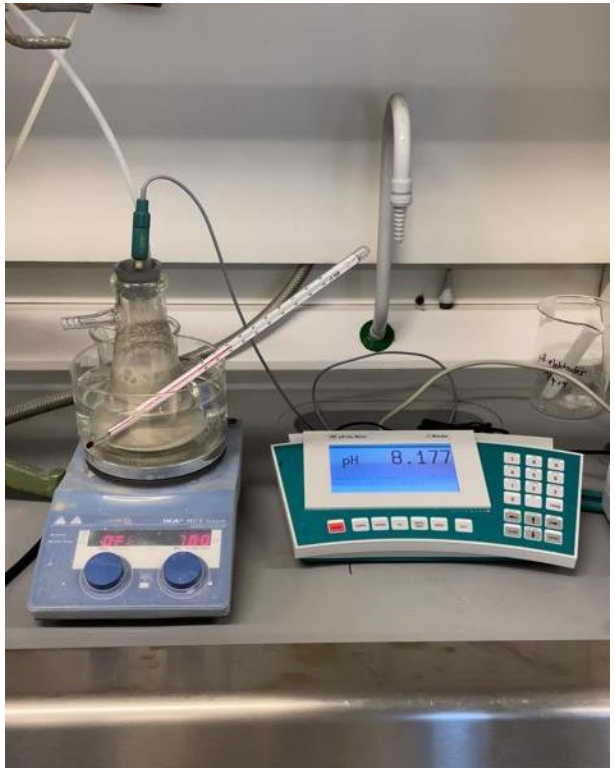
2 Enforced Carbonation

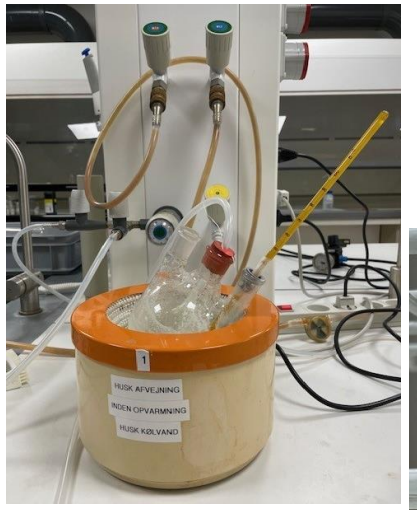
Wet carbonation

- 3 x cP-N
- 3 x cP-E-1
  3 x cP-E-14
- 3 x cP-O-1



- ✓ 20 grams of paste
- ✓ Water/solid mass ratio=10
- ✓ Gas flow rate= 2.0 L/min
- ✓ 25% CO_2 / 75% N_2

Drying under N2



- ✓ Avoid filtering – it is best drying the whole sample.

Lab set-up

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Hydrated cement paste

1 Natural carbonation

2 Enforced Carbonation

3 Post-Natural Carbonation

1 week, Environment (lab) conditions

CO_2 determination #1

CO_2 determination #2

CO_2 determination #3

CO_2 determination #4

Carbonation results

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It is important to measure the CO_2 content of the **starting material** prior to experiments to establish a **baseline**

N: Nitrogen atmosphere, glove bag
E: CO_2: 366±12 ppm, RH: 26±9%, T: 23±0.3°C
O: CO_2: 153±17 ppm, RH: 40±1%, T: 40±1°C

Carbonation results

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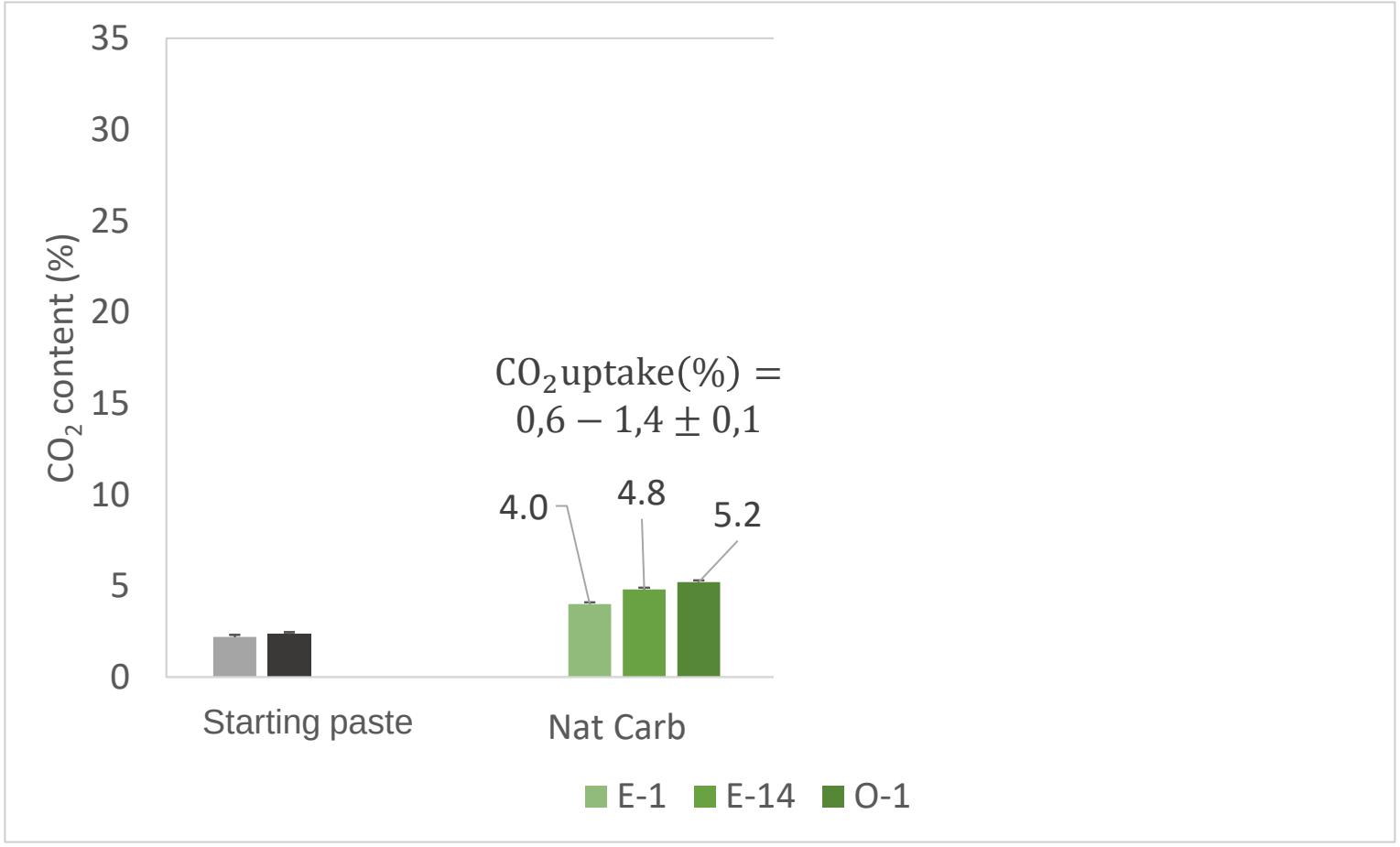
$$CO_2 uptake = \Delta\left[CO_{2,Carbonated} - CO_{2,Fresh}\right]_{LOI\ free} \times (1 - LOI_{Fresh})$$



It is important to measure the CO_2 content of the **fresh material** prior to experiments to establish a **baseline**

P's CO_2 uptake due to **natural carbonation is rather low, still must be prevented.**

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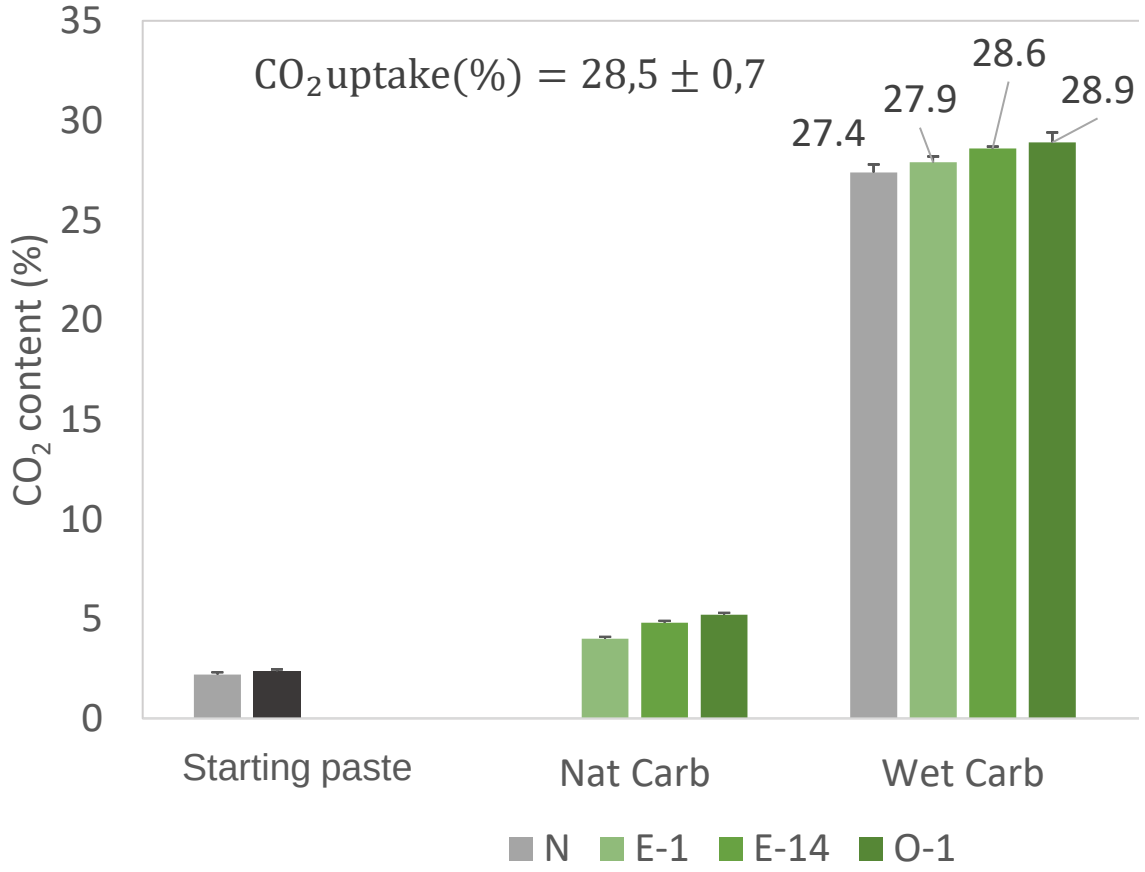

It is important to measure the CO_2 content of the **fresh material** prior to experiments to establish a **baseline**

P's CO_2 uptake due to **natural carbonation is rather low, still must be prevented.**

CO_2 uptake from **enforced carbonation is not affected by natural carbonation**, since all tested exposure conditions yield similar final contents.

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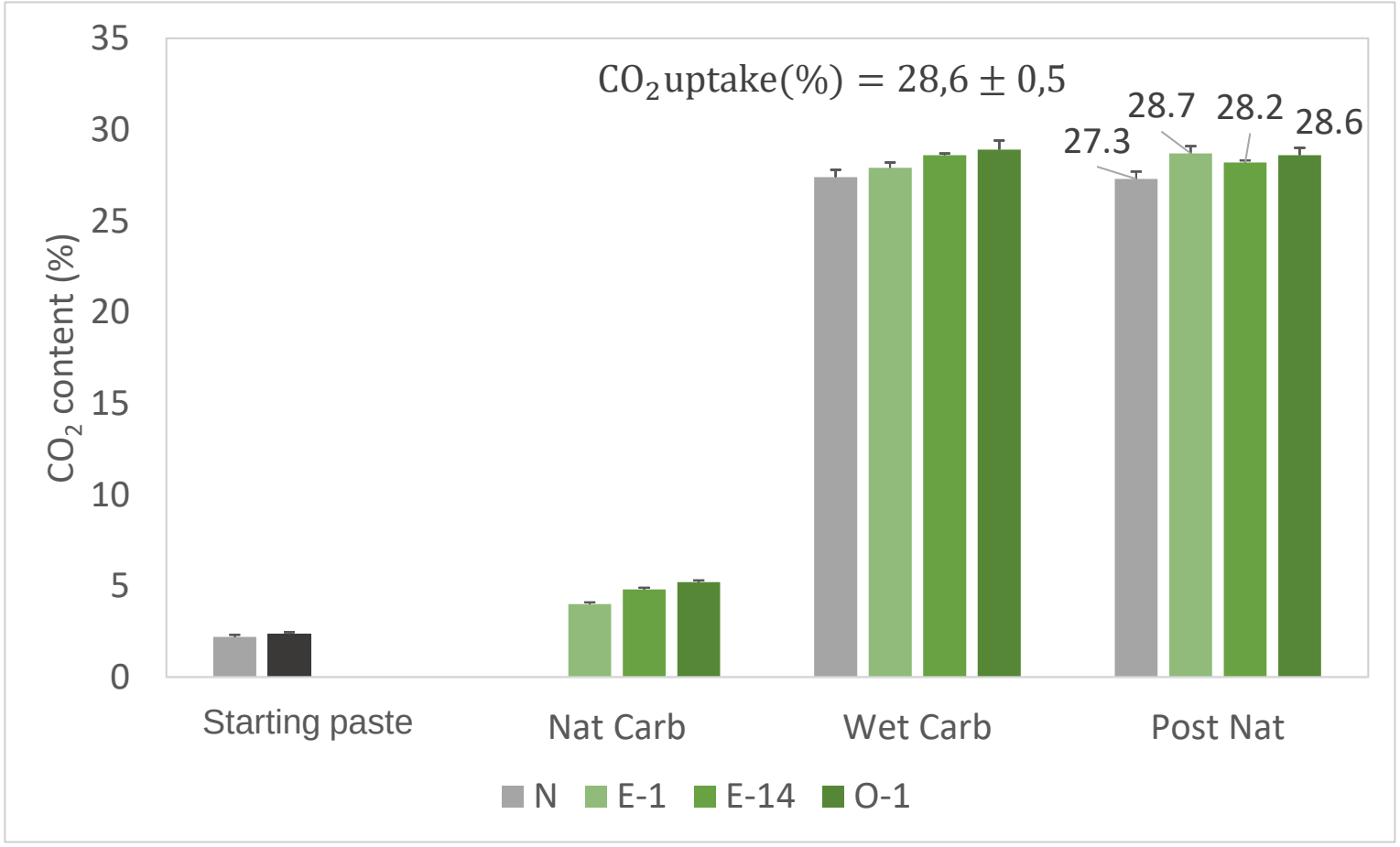

It is important to measure the CO_2 content of the **fresh material** prior to experiments to establish a **baseline**

P's CO_2 uptake due to **natural carbonation is rather low, still must be prevented**.

CO_2 uptake from **enforced carbonation is not affected by natural carbonation**, since all tested exposure conditions yield similar final contents.

No further natural carbonation – or a rather negligible amount – takes place after enforced carbonation.

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E: CO_2: 366±12 ppm, RH: 26±9%, T: 23±0.3°C
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Evaluation of carbonated products

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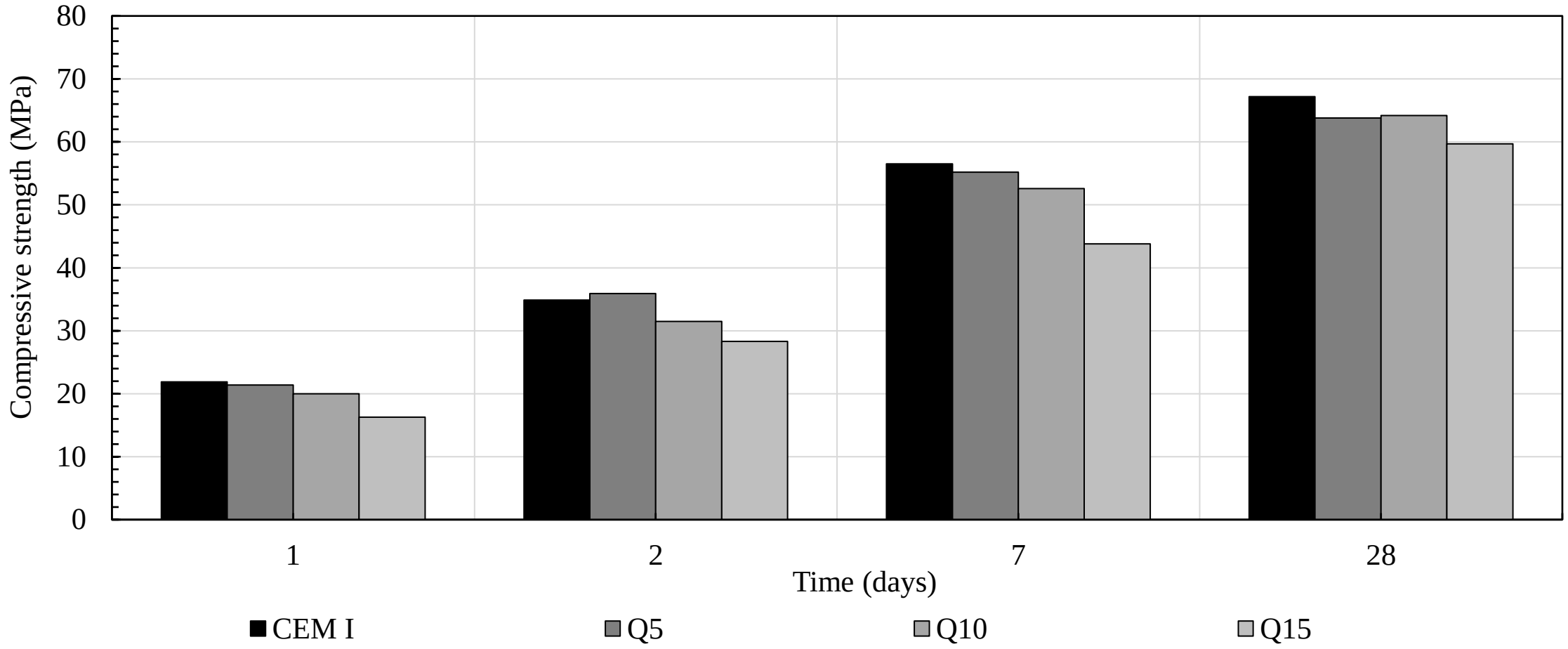
- Cem I-52.5
- Q: Ground quartz <90µm
- Numbers indicate weight replacement (%)



Evaluation of carbonated products

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- P: Paste
- c-P: Carbonated Paste
- Q: Ground quartz <90µm
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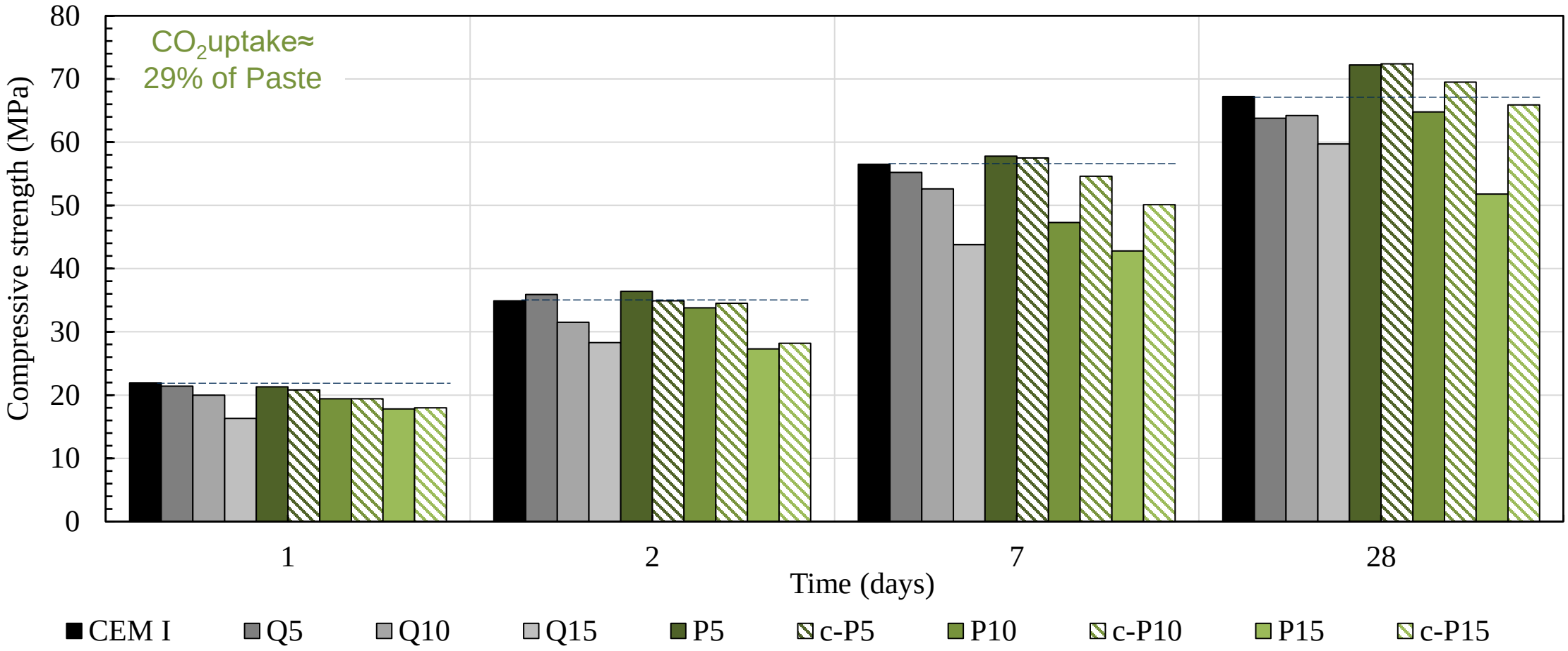

Main learnings

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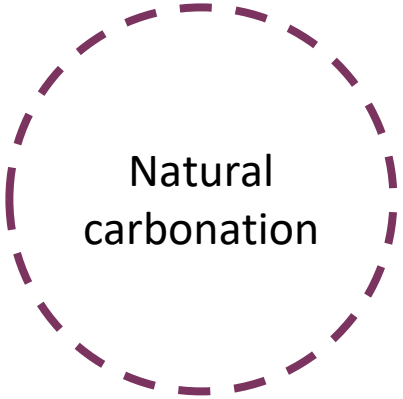
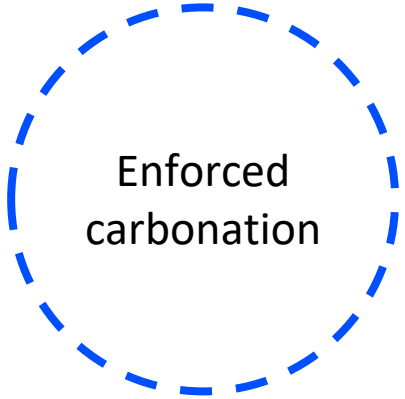


- ✓ Proper assessment of the initial carbonate state for a reliable quantification.
- ✓ Extension of natural carbonation is rather low.
- ✓ Implement control measurements to keep baseline constant.



- ✓ CO_2 uptake from enforced carbonation is not affected by the starting state.

- ✓ Up to 28 days, replacing up to 10% of cement with cP does not compromise the cement's fc performance significantly.

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Thank you