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Frost Resistance of Low-Carbon Concrete

LOPPUWEBINAARI – 29.4.2024

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Compositions & Curing Conditions

w/b = 0,45; Binder content: 430 kg/m³

Target Slump = 150 ± 25 mm

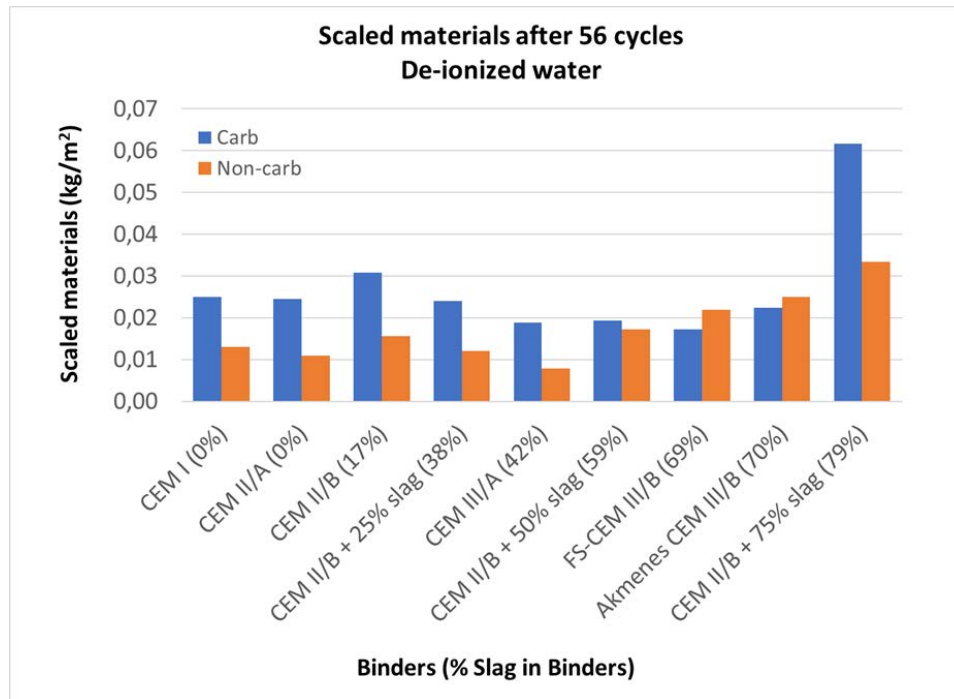
Target Air Content = 5 ± 1%; A.E.A = 0,1% Binder

Binders	Slag Content (%)	Super Plasticizer (%)
CEM I	0	0,35
CEM II/A	0	0,18
CEM II/B	17	0,18
CEM II/B + 25% Slag	38	0,12
CEM III/A	42	0,10
CEM II/B + 50% Slag	59	0,06
FS-CEM III/B	69	0
Akmenes-CEM III/B	70	0
CEM II/B + 75% Slag	79	0

Curing conditions

- Non-Carbonated, standard procedure by (CEN/TS 12390-9:2016)
- Accelerated carbonation at 3 ± 0,5% CO₂ (62 d)
- Natural carbonation at 65% RH (1 year)

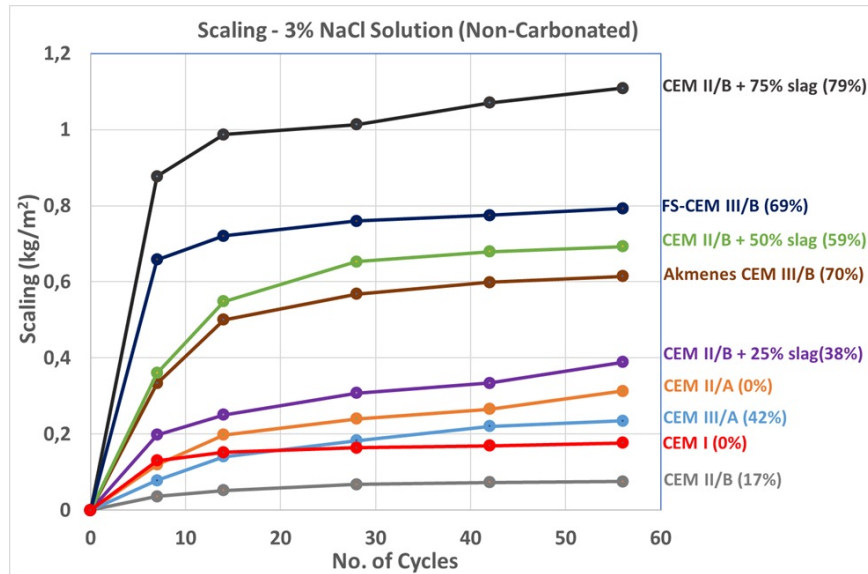
Slab test, freeze-thaw without chlorides carbonation effect



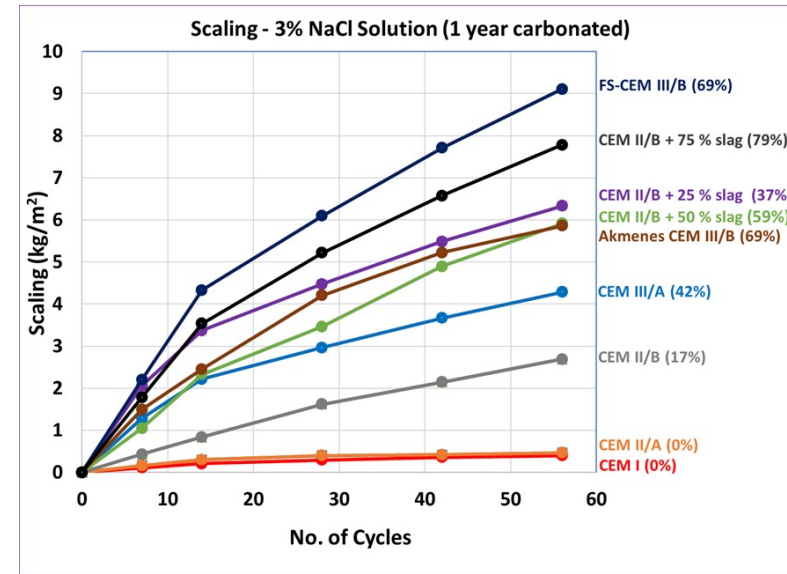
- Accelerated carbonation 62d
- Non-carbonated, standard procedure

XF1 and XF3

Slab test, salt freeze-thaw – carbonation effect

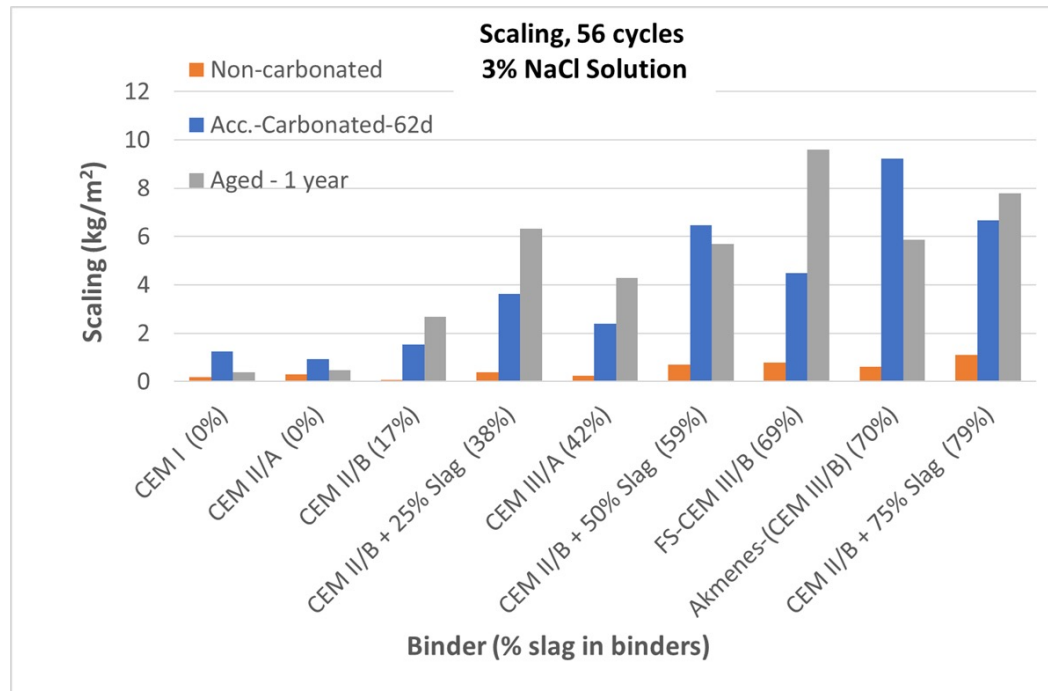


**Non-carbonated,
Standard procedure**



**Natural carbonation,
1 year, 65% RH**

Slab test, salt freeze-thaw – carbonation effect

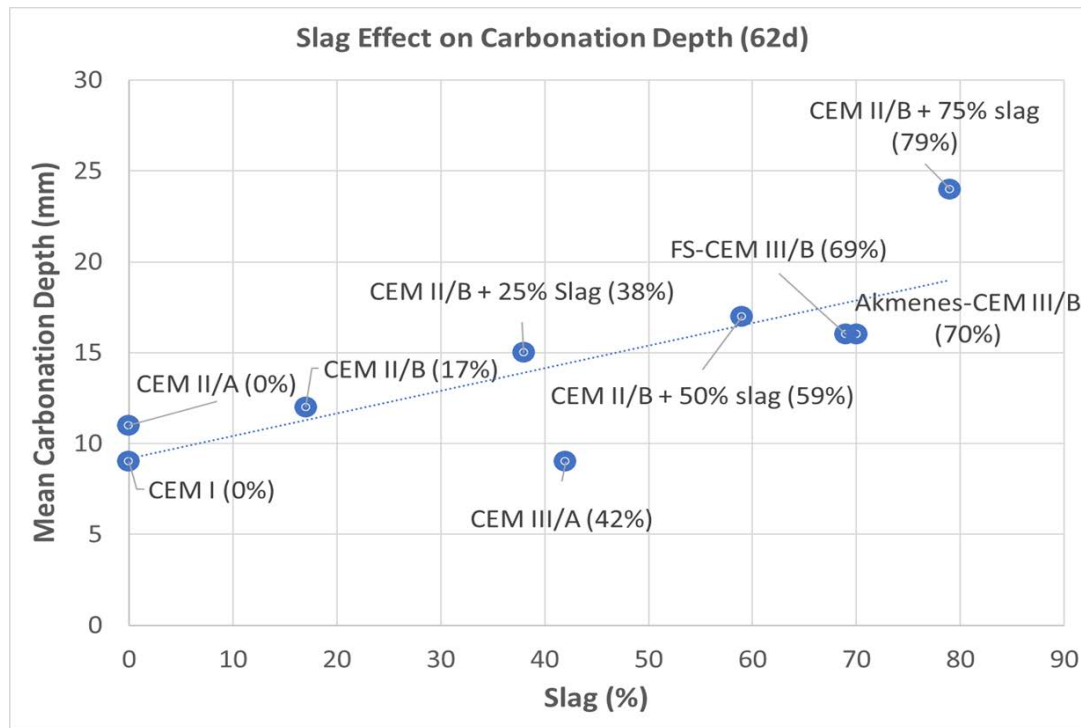


Curing conditions

- Non-Carbonated, standard procedure by (CEN/TS 12390-9:2016)**
- Accelerated carbonation at ($3 \pm 0,5\% \text{ CO}_2$ (62 d)**
- Natural carbonation at 65% RH (1 year)**

Effect of Slag on Carbonation depth

Accelerated Carbonation (62 Days)
CO₂ concentration (3,0 ± 0,5)%

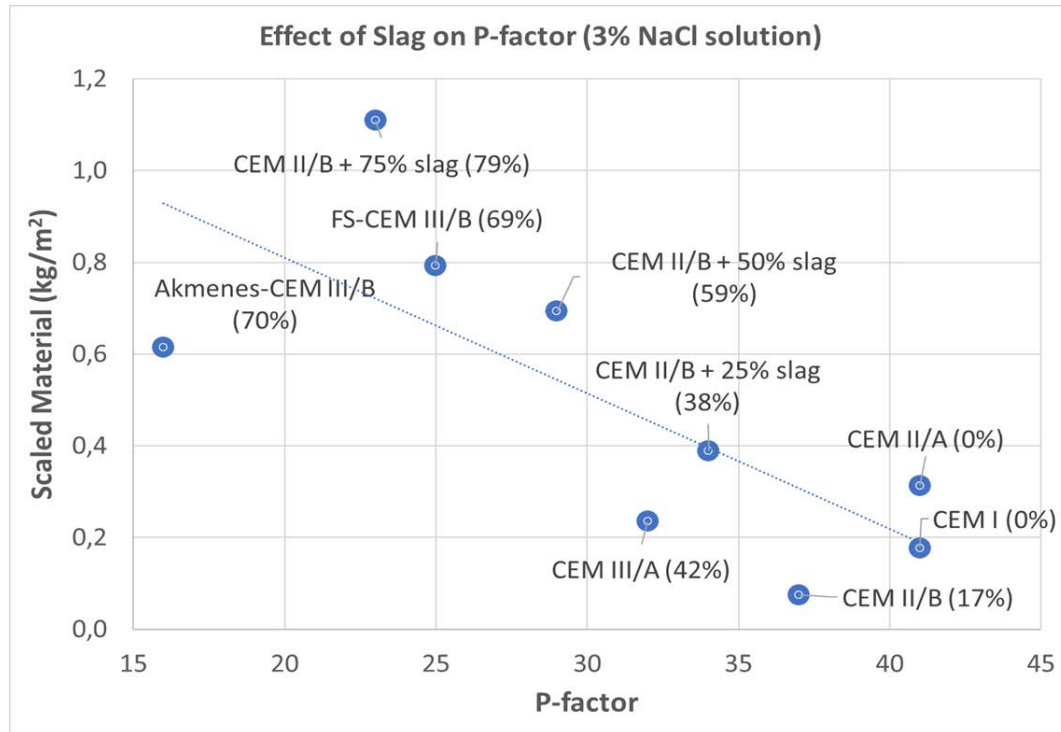


CEM II/A (0%)



CEM II/B + 75% slag (79%)

Correlation of P-factor with scaling



- P-factor correlated rather well with the scaling values

Effects of curing conditions & testing age

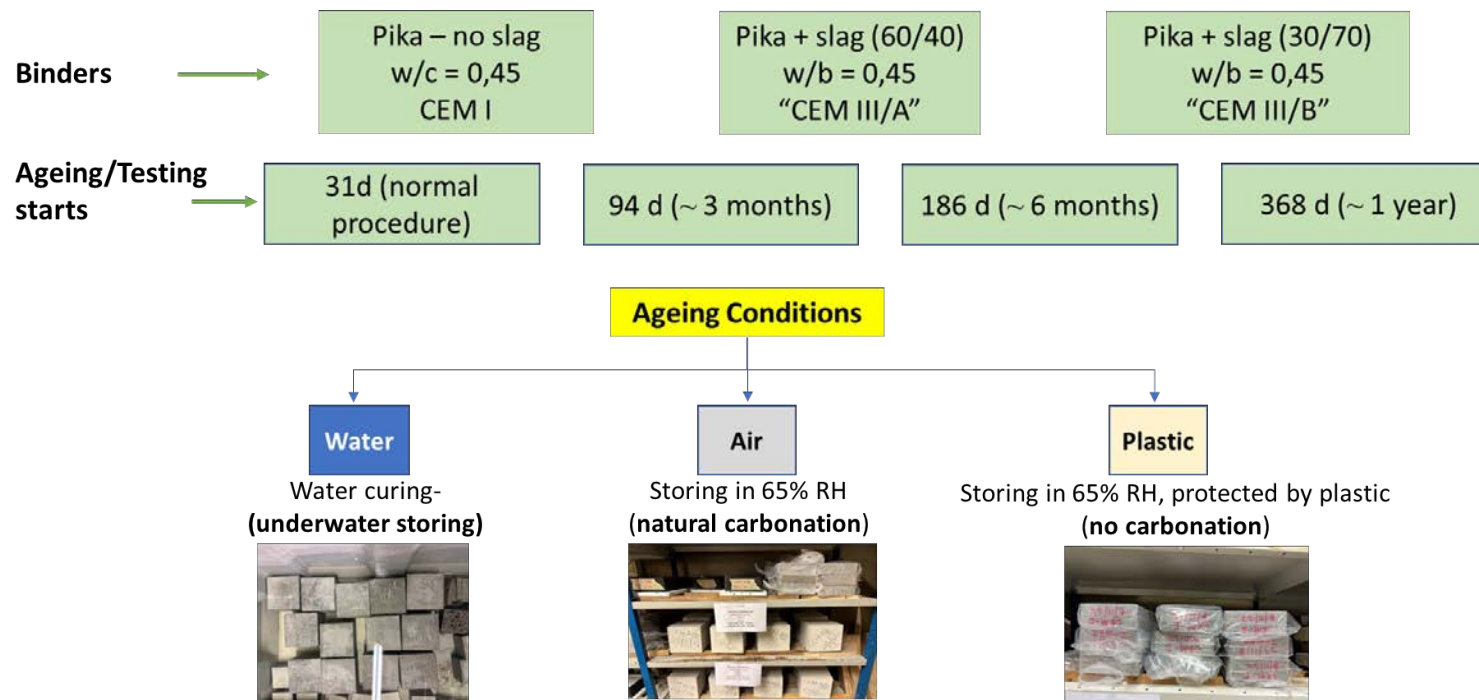


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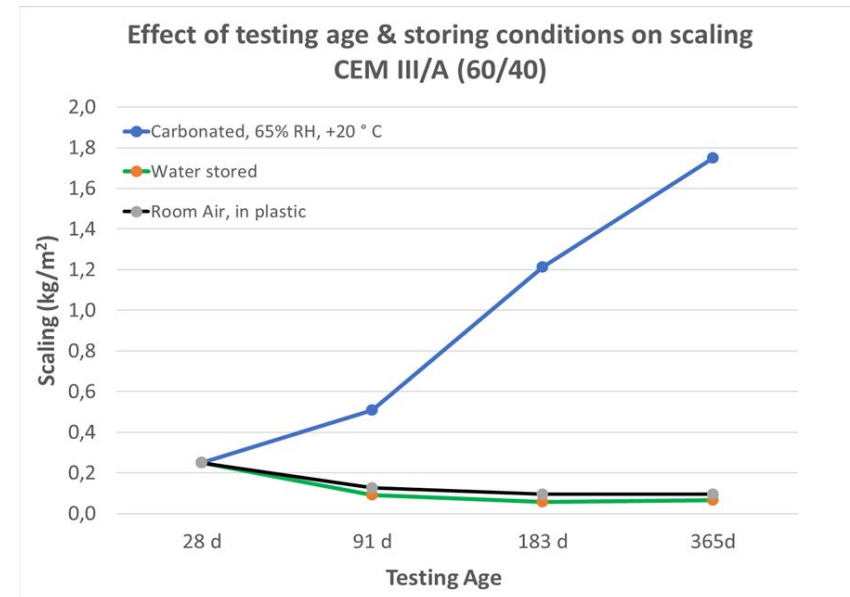
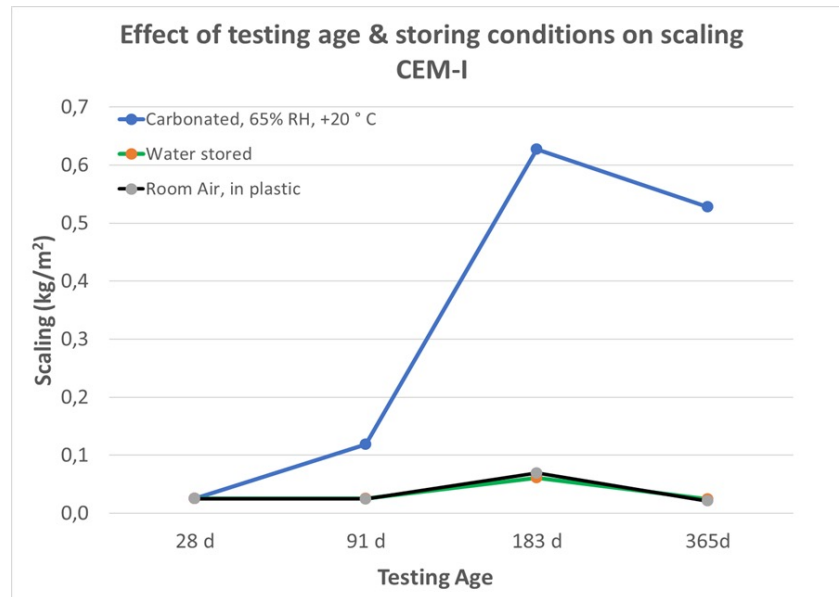
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Research Objectives & Testing Program

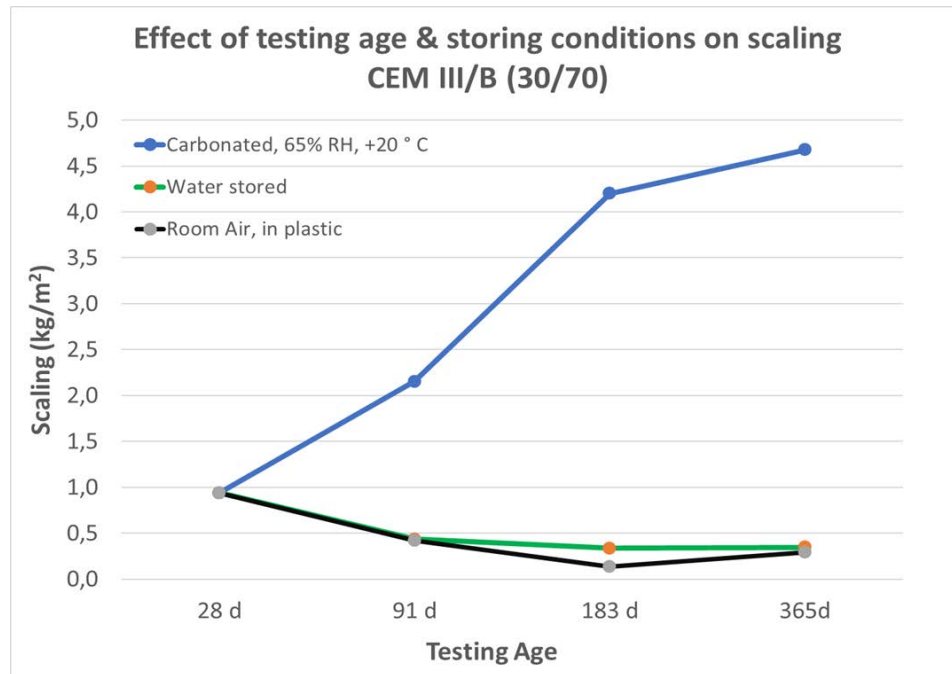
- Study the effects of storing conditions & testing age on salt freeze-thaw resistance



Slab test, salt freeze-thaw – effects of curing & testing age



Slab test, salt freeze-thaw – effects of curing & testing age



- Carbonation increase scaling, especially much higher in “CEM III/B”.
- Storing conditions have clear effect on scaling values.

Conclusions

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Effect of slag content and carbonation

- Slag content has clear effect on salt freeze-thaw resistance (XF2 and XF4), **50% slag content is critical.**
- Freeze-Thaw resistance of concrete without salt (XF1 and XF3) appears to be good.
- Ageing/Carbonation has clear effect on scaling.
- P-factor correlates with scaling.

Effects of curing and testing age

- Carbonation increase scaling with all the cement types, biggest absolute effect with CEM III/B
 - Plastic protected & water stored specimens had very similar scaling, thus carbonation is critical.
- Longer storing time reduced scaling significantly.
 - CEM III: 28d → 91d reduced scaling by 50%,
- Carbonation correlated with slag content

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