

Salt freeze scaling of OPC-slag-cements vs. carbonation

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Frontrunner in
green construction

FINNSEMENTTI
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Finnsementti locations



Parainen



Henkilöstö

n. 130



Lappeenranta



Henkilöstö

n. 75

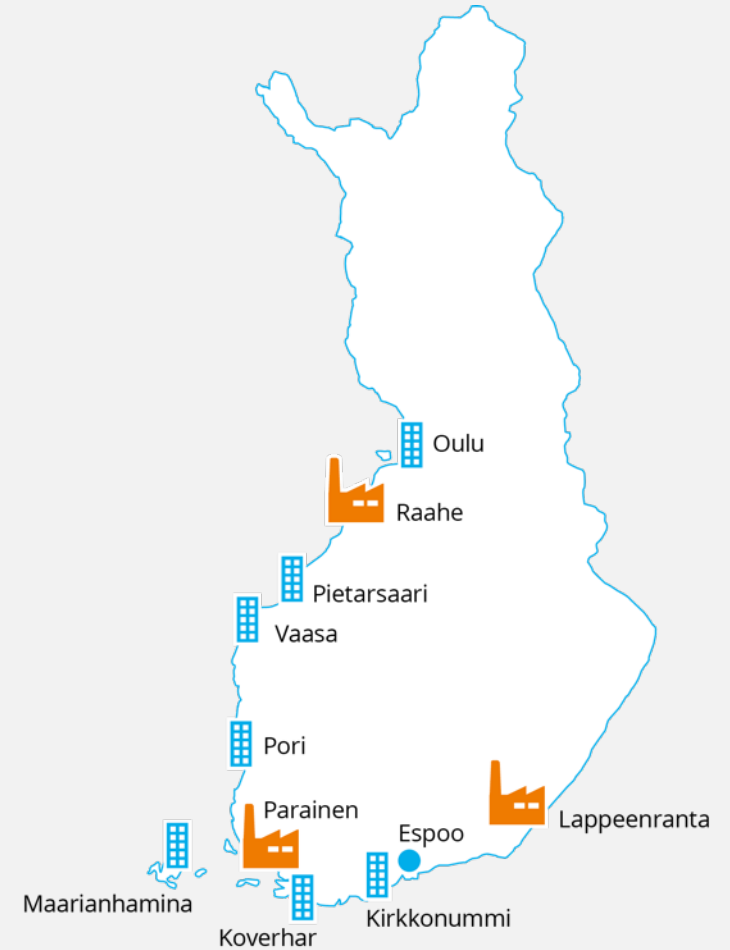


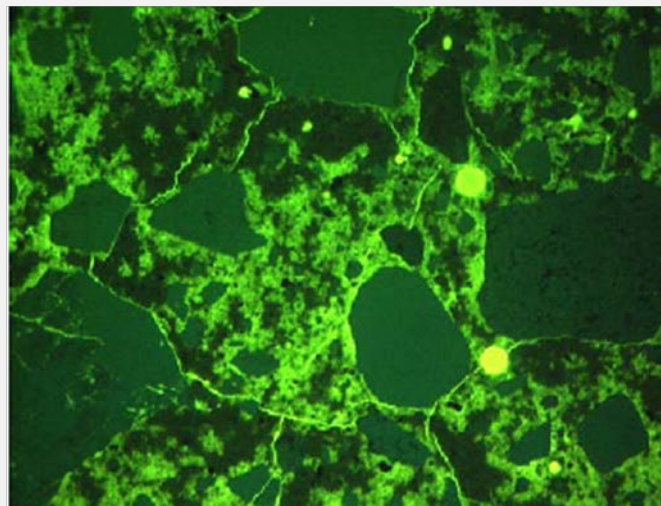
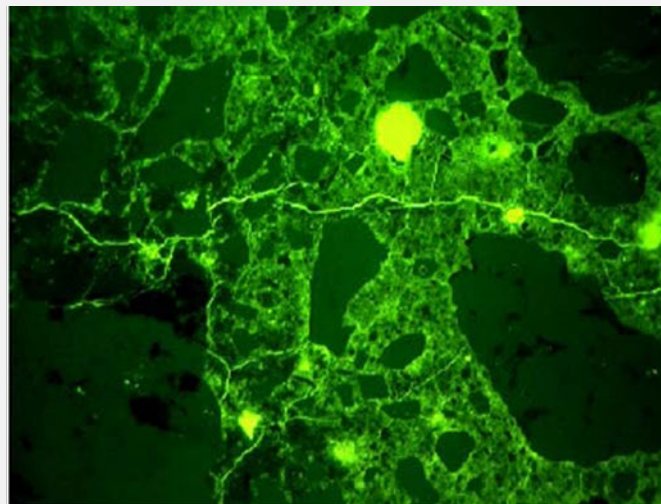
Raahe



Henkilöstö

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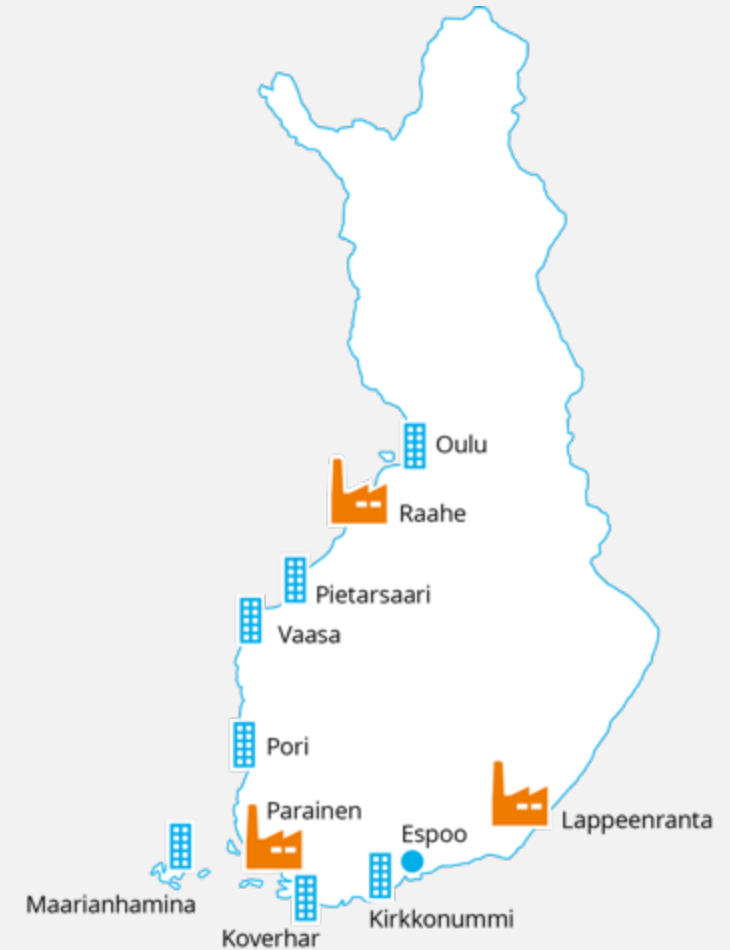
Kolmos
SEMENTTI

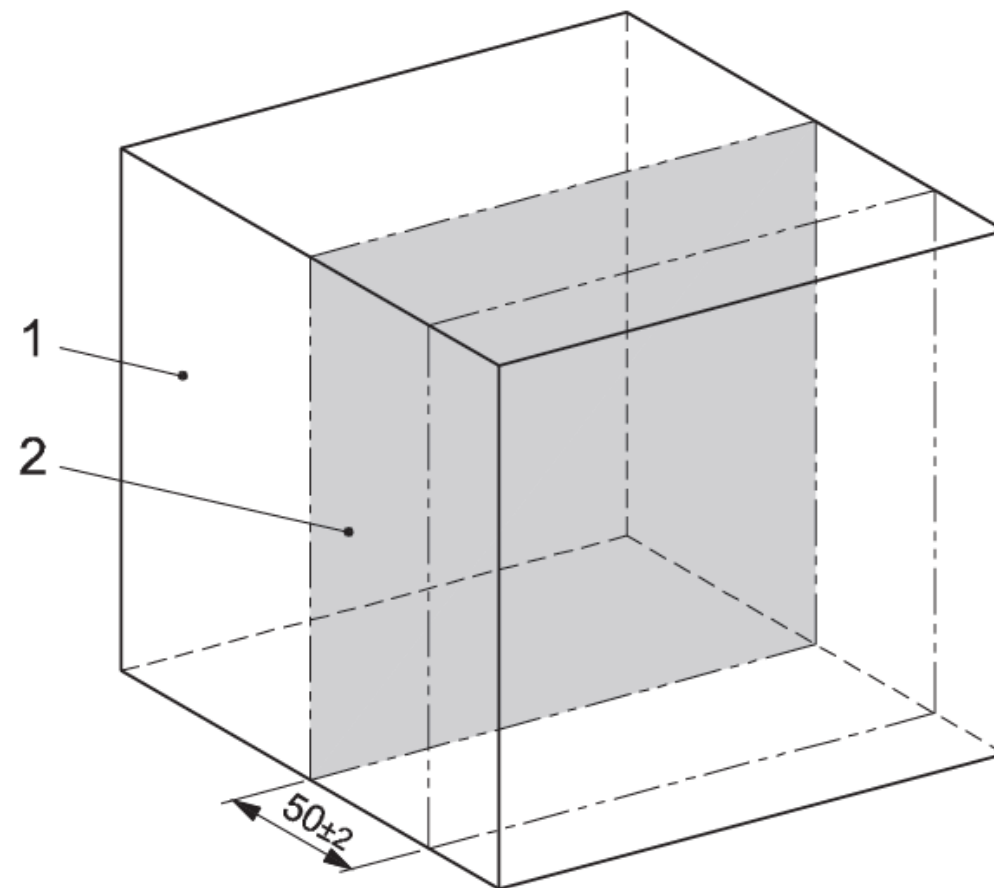


SemNet

Two recent damage theories

- the glue spall theory
- the cryogenic suction theory







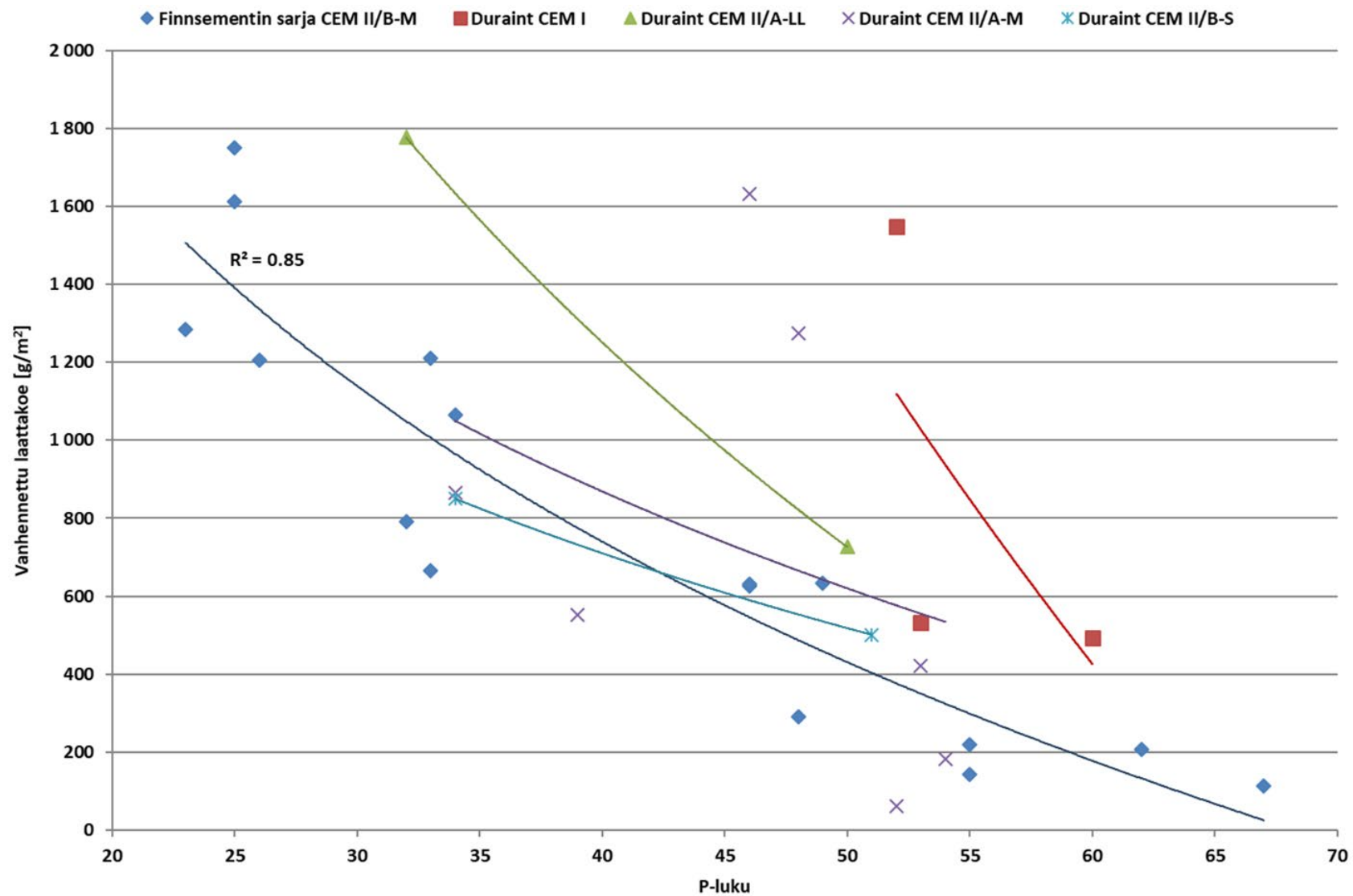
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Vesikari mid-80s frost resistance value.

Effects of carbonation on the pore structure of granulated blast furnace slag concrete, Seppo Matala 1995





	Recipe A				Recipe B				Recipe C			
	Mix 1	Mix 2	Mix 3	Mix 4	Mix 5	Mix 6	Mix 7	Mix 8	Mix 9	Mix 10	Mix 11	Mix 12
Test Date	23/11/2021	18/11/2021	18/11/2021	22/11/2021	23/11/2021	24/11/2021	24/11/2021	25/11/2021	01/12/2021	01/12/2021	07/12/2021	07/12/2021
Cem III/A [kg/m ³]	325	324	324	325	410	410	410	410	433	435	436	435
Water [kg/m ³]	158	157	157	158	164	164	164	164	154	155	155	155
SP [%]	0,39	0,385	0,39	0,39	0,57	0,57	0,57	0,57	0,89	0,89	0,89	0,89
AEA [%]	0,012	0,012	0,012	0,012	0,02	0,02	0,02	0,02	0,036	0,036	0,036	0,036
W/C	0,49	0,48	0,48	0,49	0,40	0,40	0,40	0,40	0,36	0,36	0,36	0,36
Air [%]	4,4	5,7	5,6	5,4	4,5	4,4	4,5	4,6	4,4	4	3,9	4
Fresh density [kg/m ³]	2257	2251	2258	2276	2318	2319	2324	2316	2359	2375	2371	2368
Slump [mm]	170	165	180	160	180	185	180	170	185	200	160	180
Strength 7d [MPa]	35	38	36	35	55	56	52	52	65	66	67	69
Strength 28d [MPa]	54	54	53	53	69	70	67	67	78	81	80	82
Strength 91d [MPa]	58	61	61	62	79	73	78	78	87	89	90	91
Density [kg/m ³]	2327	2354	2361	2324	2366	2371	2366	2370	2411	2410	2408	2410
hardened	2337	2361	2373	2353	2389	2382	2370	2383	2411	2427	2407	2414
	2342	2359	2357	2368	2391	2389	2389	2385	2417	2446	2409	2413

CEN/TS 12390-9:2016

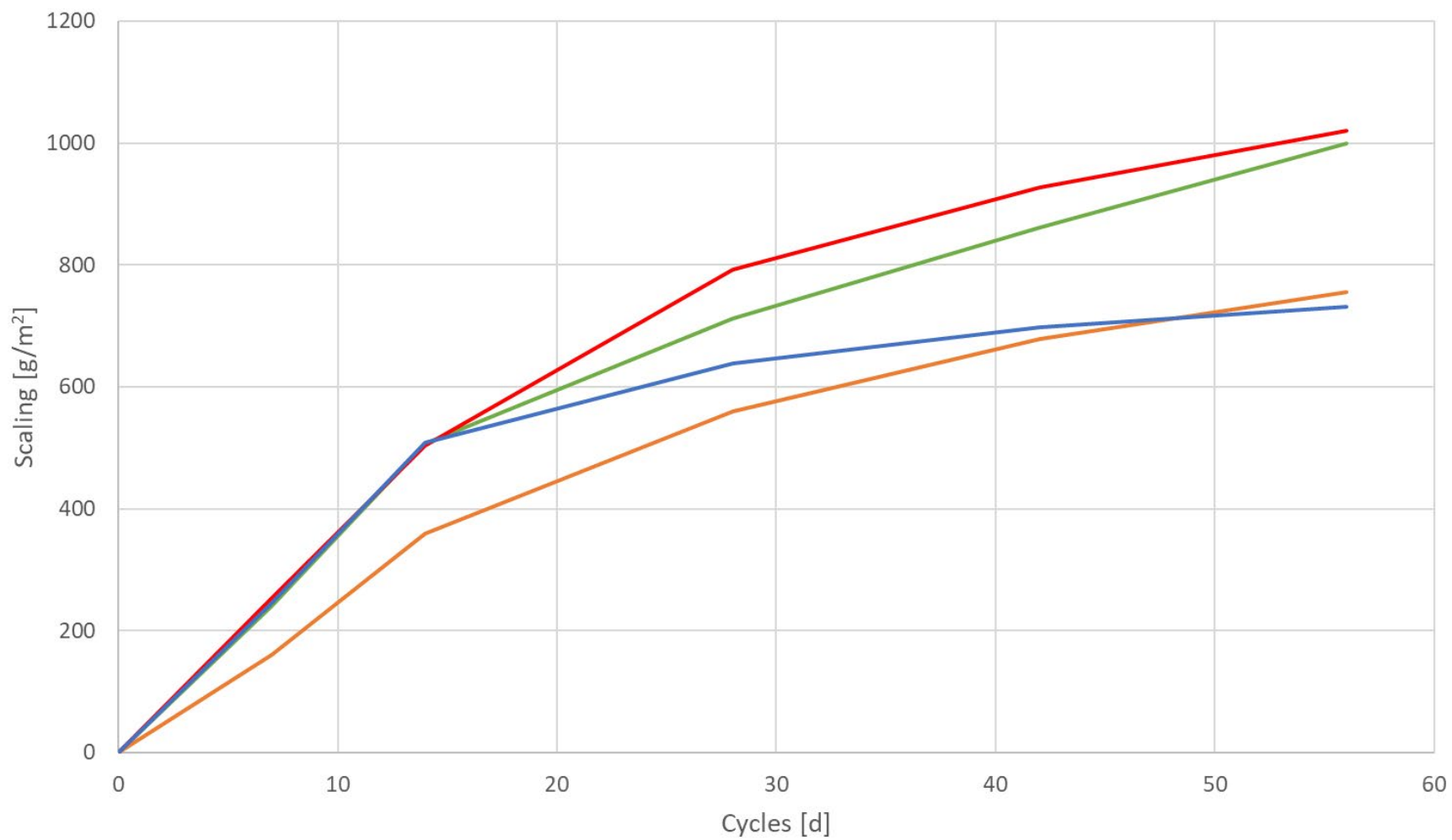
Testing hardened concrete. Part 9: Freeze-thaw resistance with de-icing salts. Scaling

Table 5 Precision data for appropriate scaling level

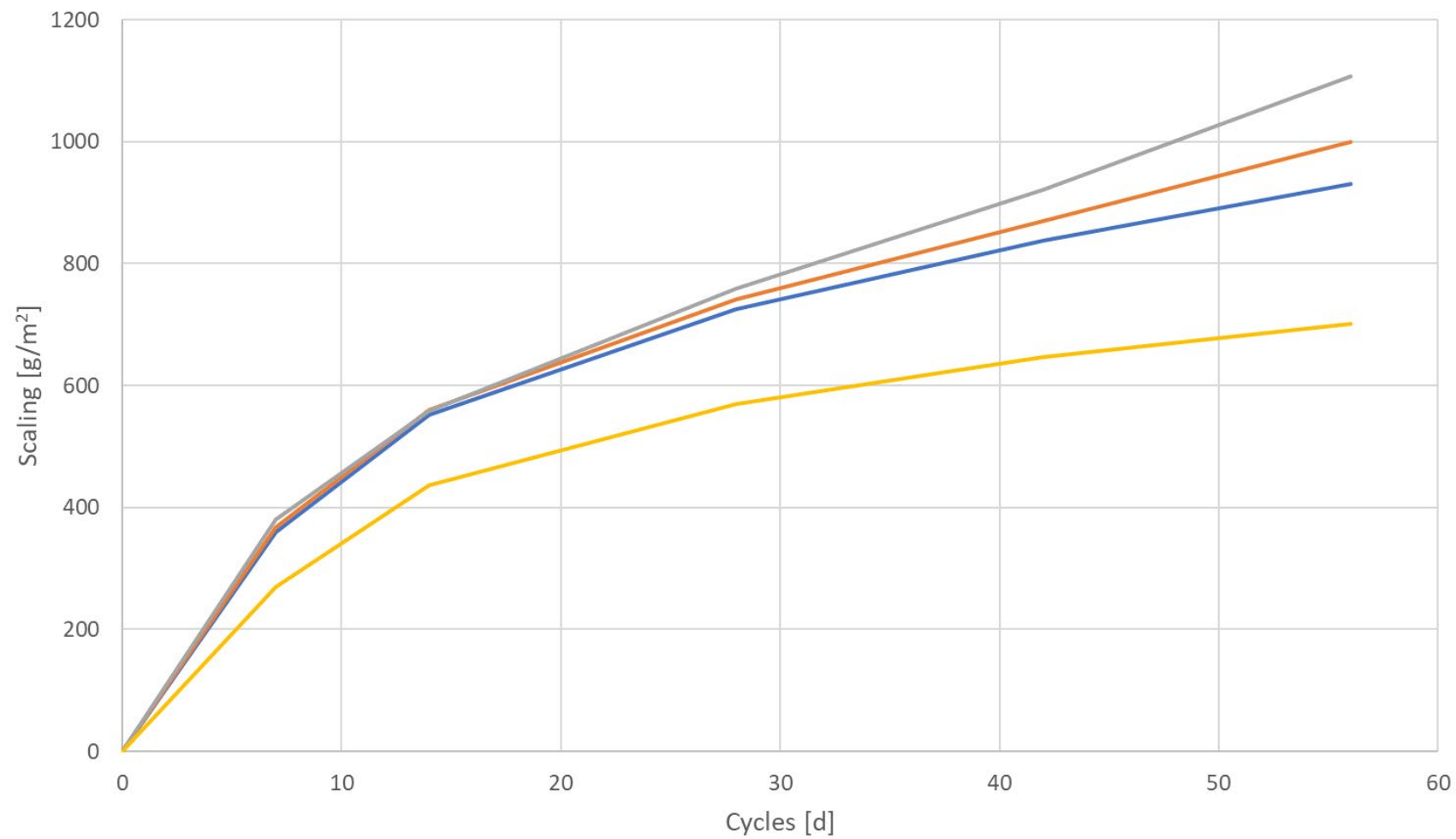
Test method	Scaling level	Coefficient of variation [%]	
		repeatability v_r	reproducibility v_R
Slab	1,0 kg/m ²	17	31
CDF	1,5 kg/m ²	14	29
cube	3 % by mass	18	38



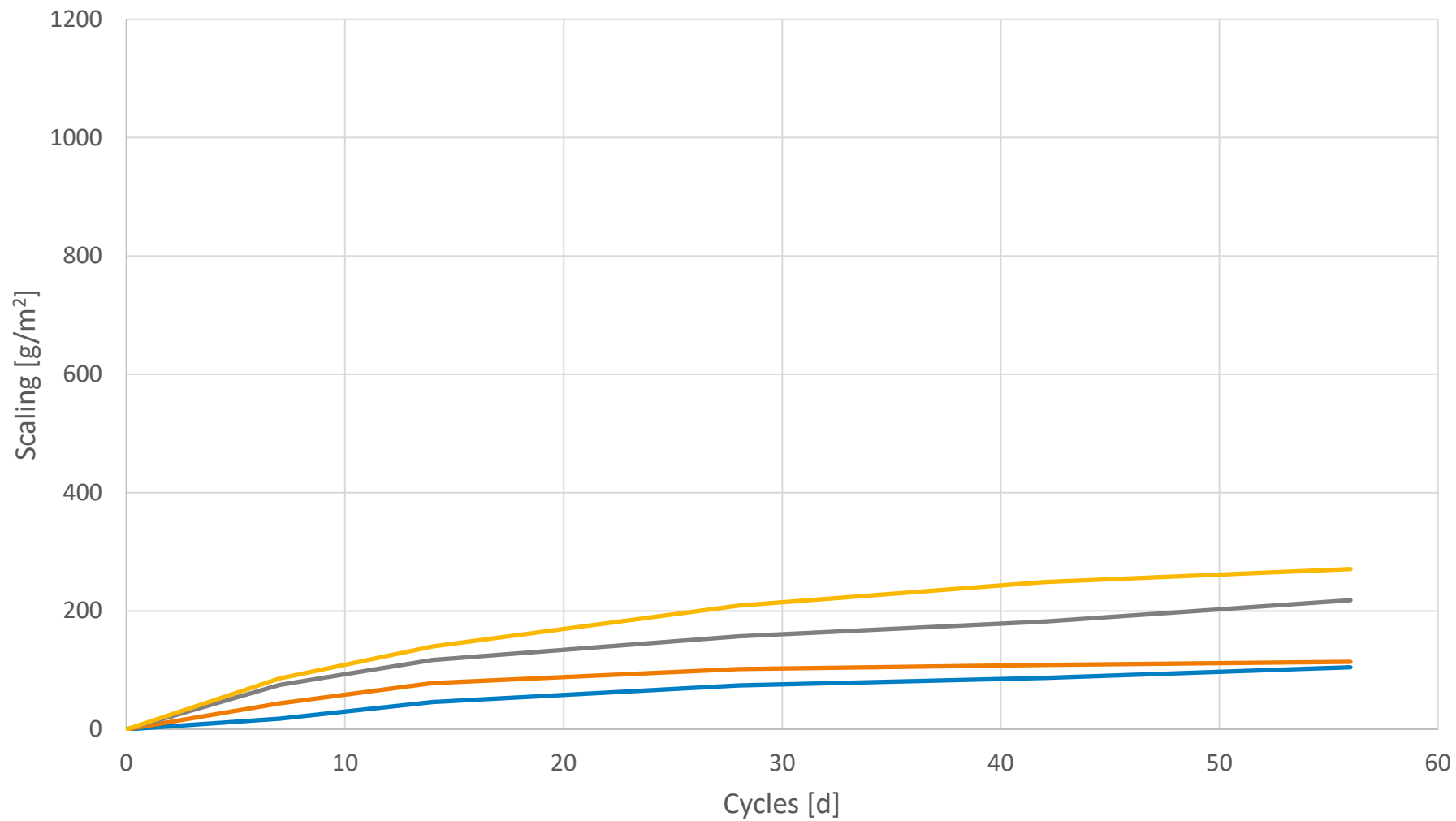
Normal scaling test Recipe A



Normal scaling test Recipe B



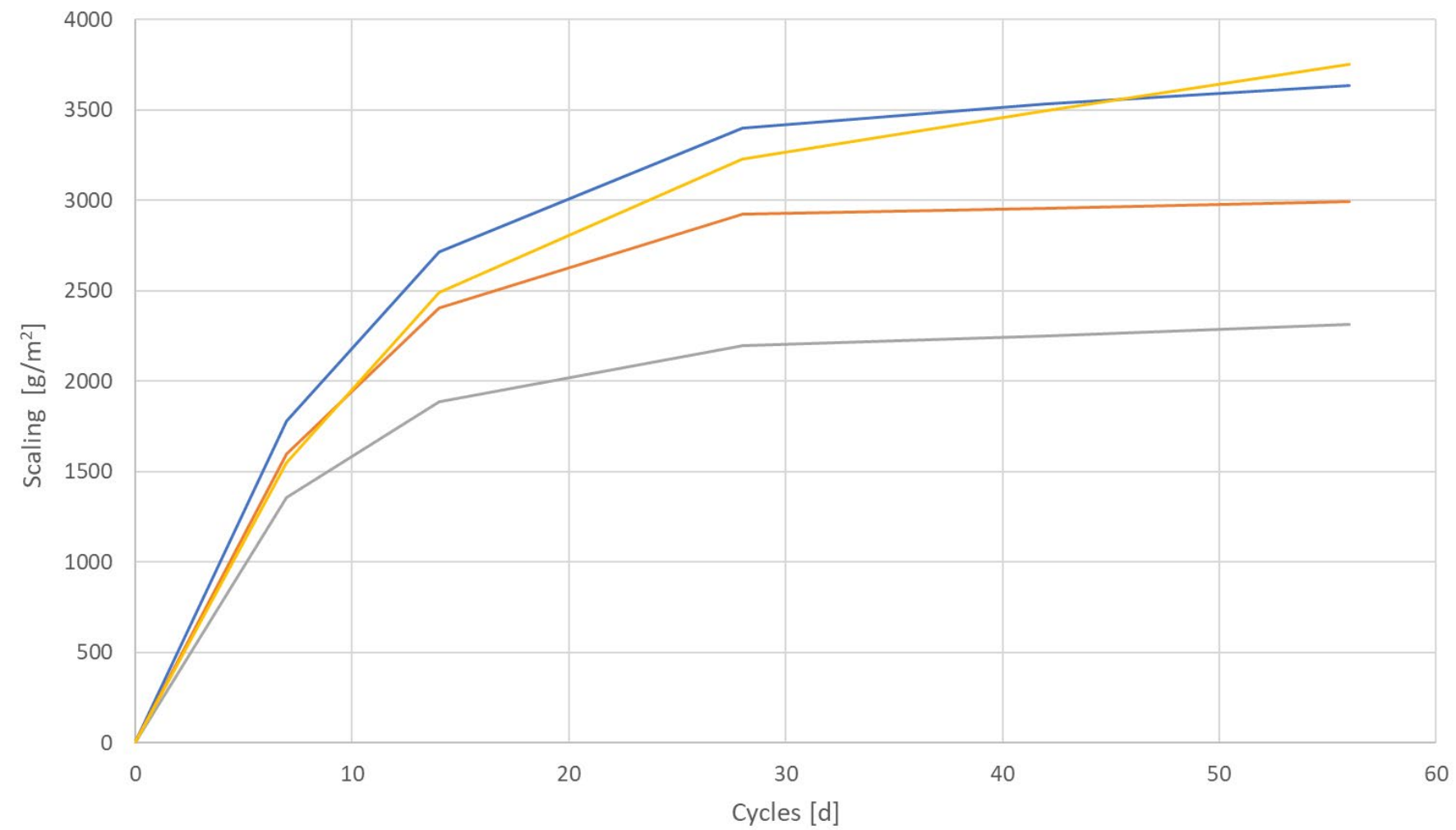
Normal scaling test Recipe C



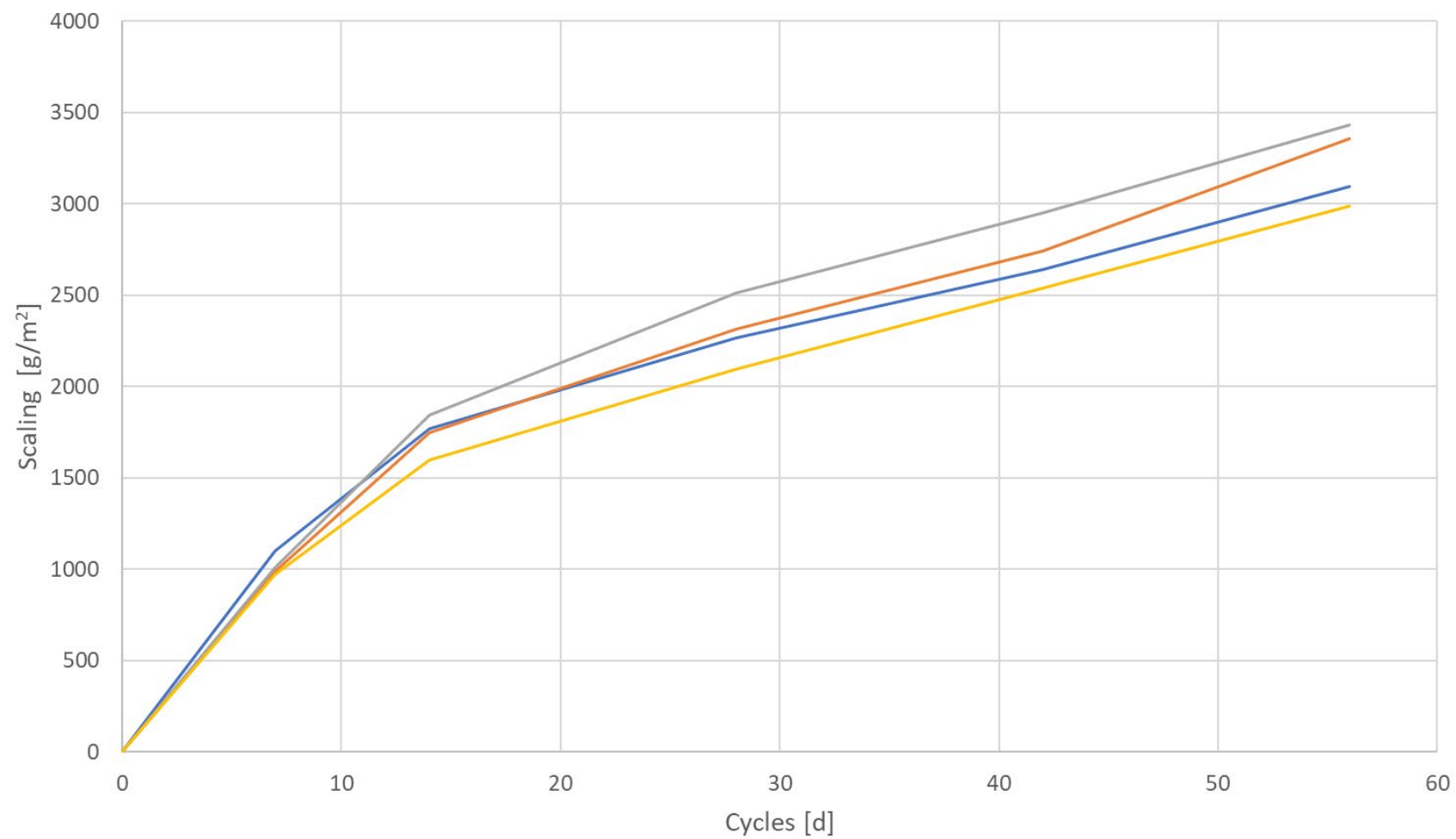
Ageing of tested concrete surfaces

- At 21 days cubes are sawn
- Storing one year in RH 70±5, +20 ± 0,5 °C and natural CO₂ –content
- Then continue normally according to CEN/TS 12390-9

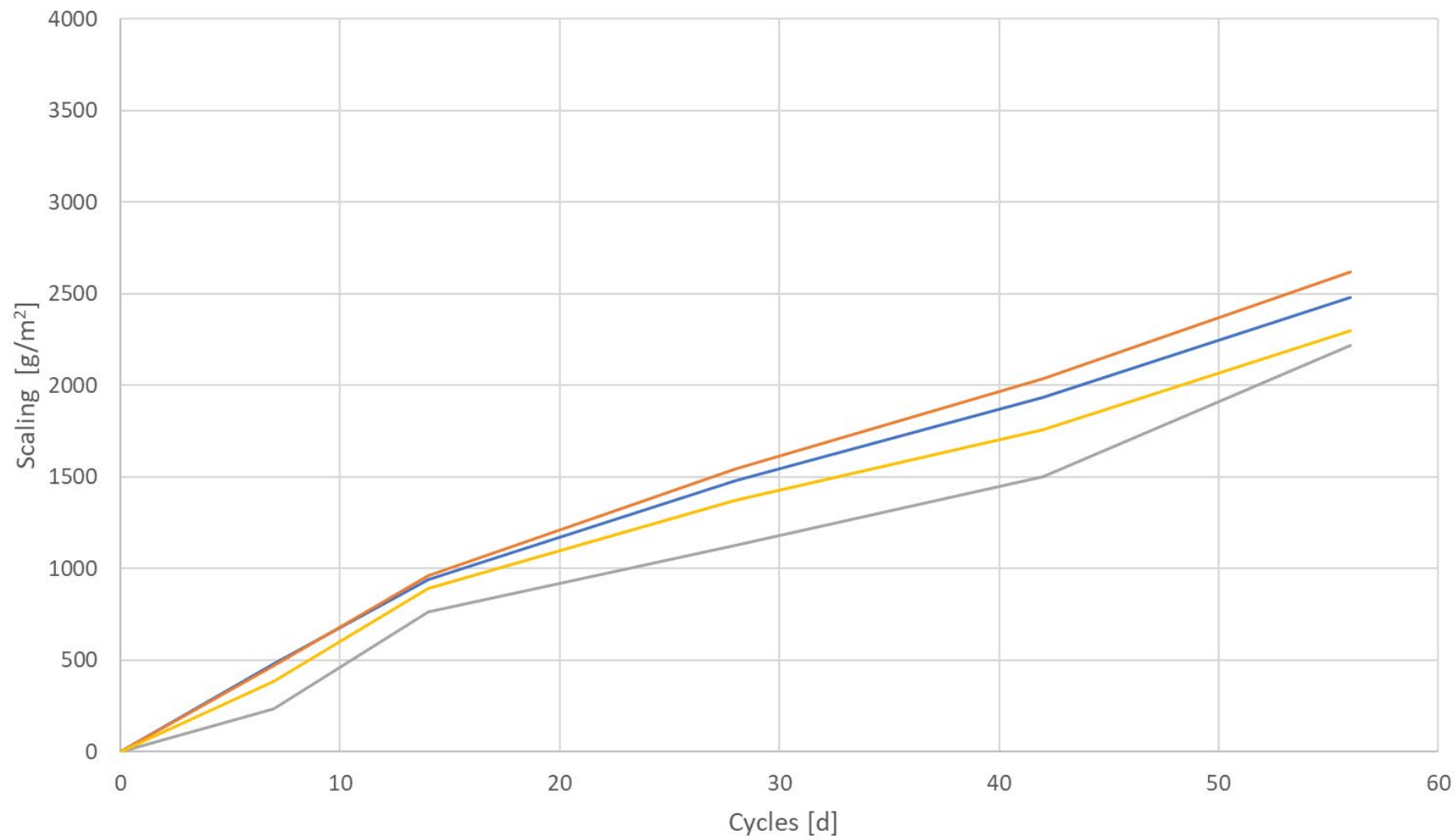
Aged scaling test Recipe A



Aged scaling test Recipe B



Aged scaling test Recipe C



Concrete testing - Hardened concrete -
Scaling at freezing - SS 137244:2019

Concrete - Application of SS-EN
206:2013+A2:2021 in Sweden - SS
137003:2021



Initial testing XF4

CEM I, CEM II/A or binder combination with clinker content $\geq 80\%$

- 1) scaling $< 0,20 \text{ kg/m}^2$ @ 56 freeze cycles or
- 2) scaling $< 0,50 \text{ kg/m}^2$ @56 cycles plus that the ratio of scaling at 56 cycles/28 cycles < 2 or
- 3)112 cycles and then the requirement $< 0,50 \text{ kg/m}^2$

CEM II/B or binder combination with clinker content 65% - 80%

- Normal slab test 112 cycles and the requirement $< 0,50 \text{ kg/m}^2$ *and*
- Slab test with carbonated surfaces 112 cycles, requirement $< 0,50 \text{ kg/m}^2$



Thank you !

