AARHUS UNIVERSITY

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The Danish Council for Strategic Research

LowE-CEM-WP3

Durability of Portland cement blends including calcined clay and limestone: interaction with sulfate, chloride and carbonate ions

Performance investigations

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FLSmidth

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Objectives

- To investigate the **durability performance** of the white Portland cement (**wPc**) mortars including metakaolin (**MK**), silica fume (**SF**), limestone (**LS**)
- To explain the variations in durability performance based on change in phases (e.g. by TGA, GEMs)[1] and **microstructure** (e.g. by **MIP,** drying method, conductivity, SEM).

[1] Zhenguo Shi, Barbara Lothenbach, Mette Rica Geiker, Josef Kaufmann, Sergio Ferreiro, Jørgen Skibsted. **ICCC, Beijing 2015. (submitted)**

Binder compositions

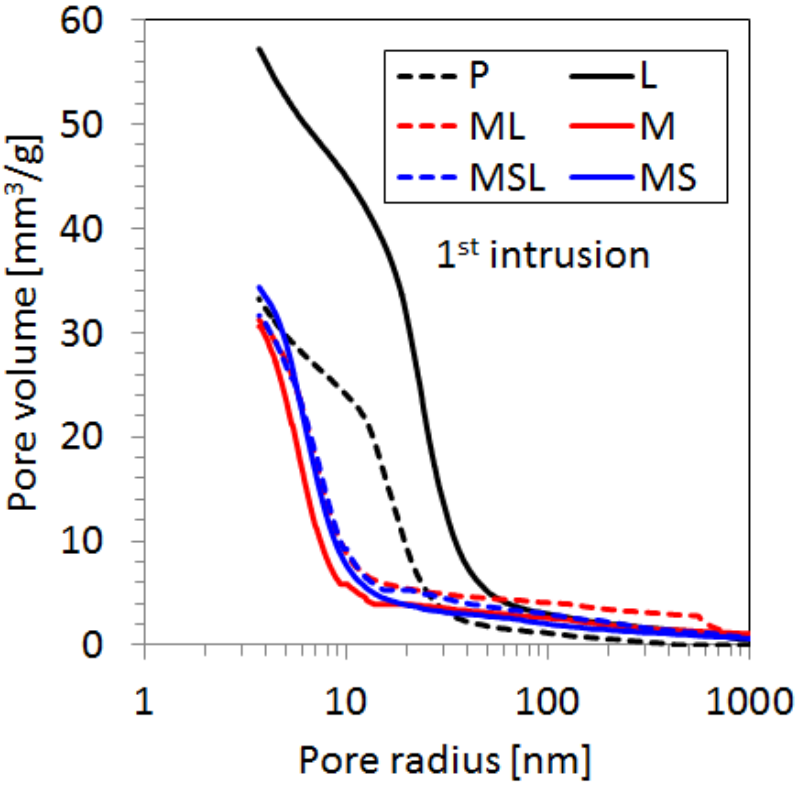
65wt% White Portland ***clinker (wPc*)*** + 35wt% (MK, SF, LS)
3.08% LS in the white Portland ***cement (wPc)***

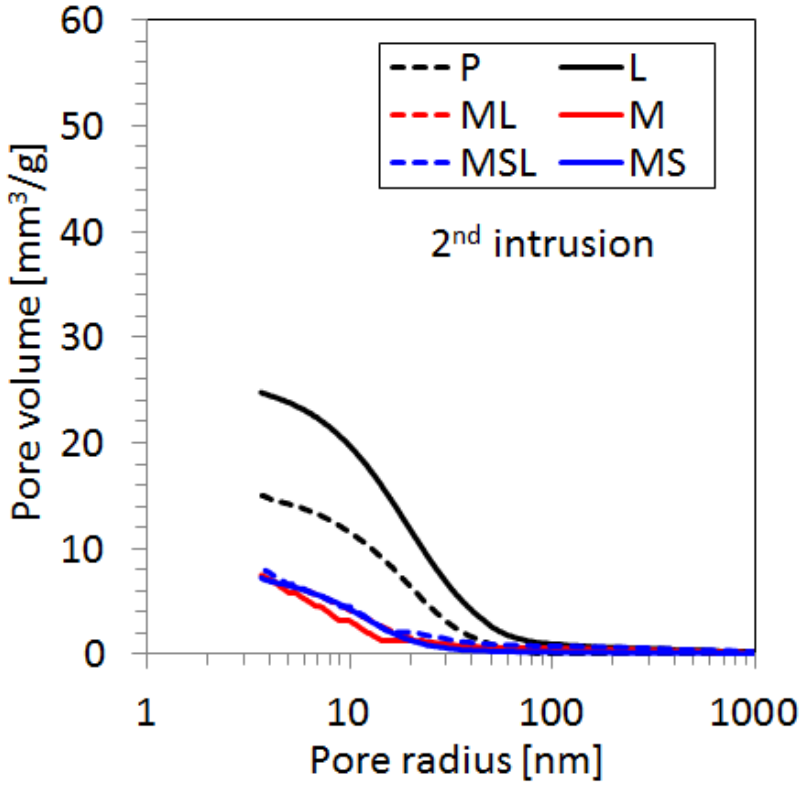
	Lables	Mix design		wPc (wt%)	MK (wt%)	SF (wt%)	LS (wt%)	Si/Al (MK+SF)
references	P	White control cement	-	100	0	0	0	-
references	L	MK/(MK+LS)	0	68.1	0	0	31.9	-
1:1 clay	ML	MK/(MK+LS)	0.75	68.1	25.5	0	**6.4**	1.13
1:1 clay	M	MK/(MK+LS)	0.94	68.1	31.9	0	0	1.13
2:1 clay minicked	MSL	(MK + SF)/(MK + SF+LS)	0.75	68.1	15.6	9.88	**6.4**	2.36
2:1 clay minicked	MS	(MK + SF)/(MK + SF+LS)	0.94	68.1	19.5	12.4	0	2.36

w/b = 0.5

Physical properties – MIP

Mortars were cured saturated for 91 days

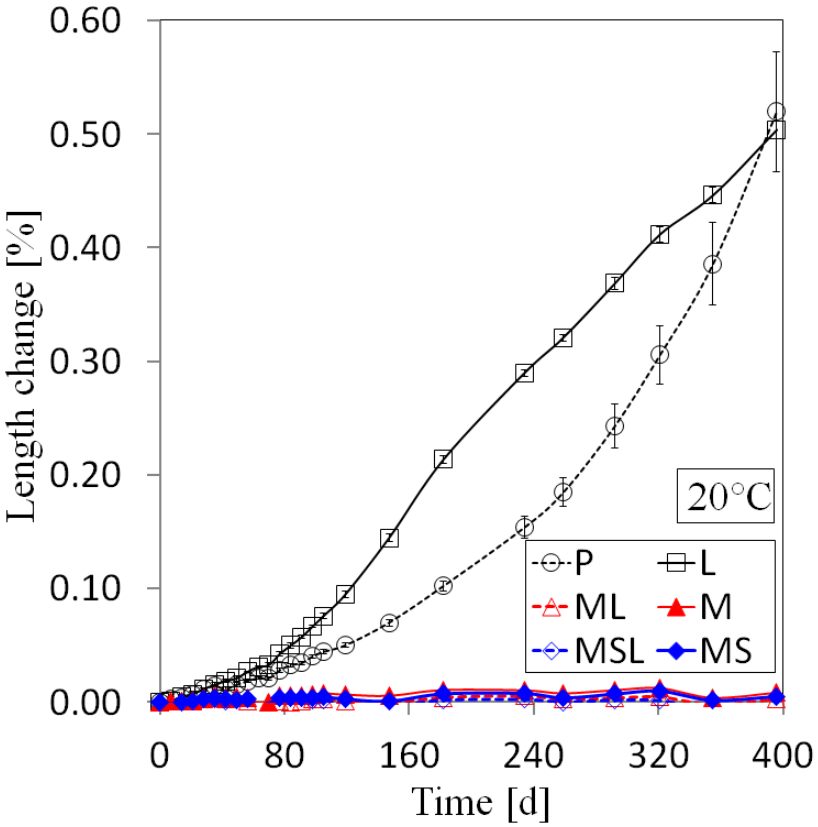


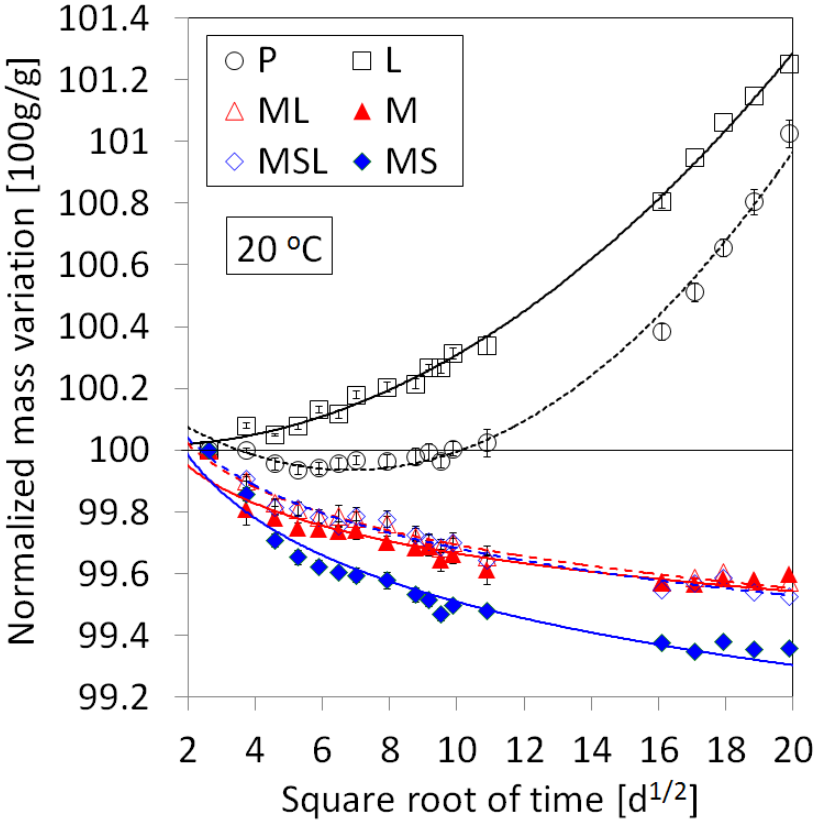



Sulfate attack

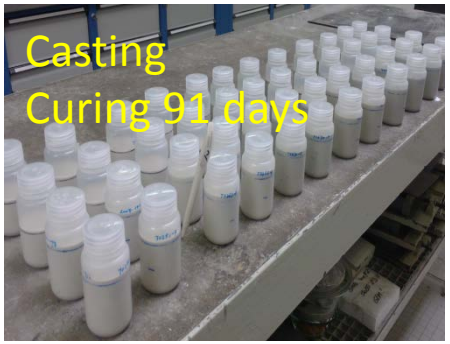
Sulfate expansions and mass variations

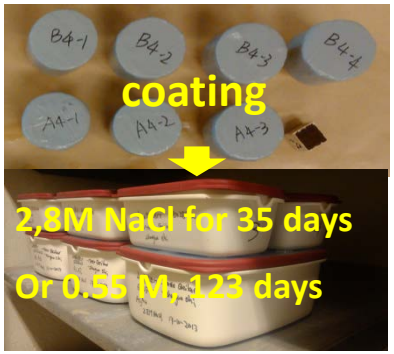
16g/L, Na_2SO_4

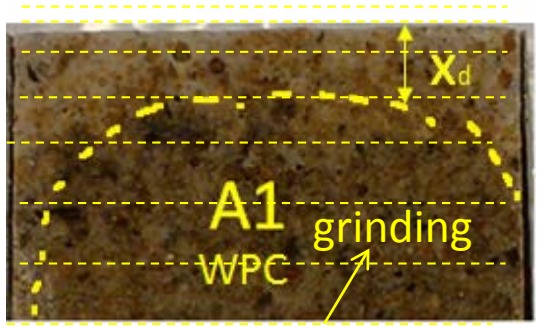


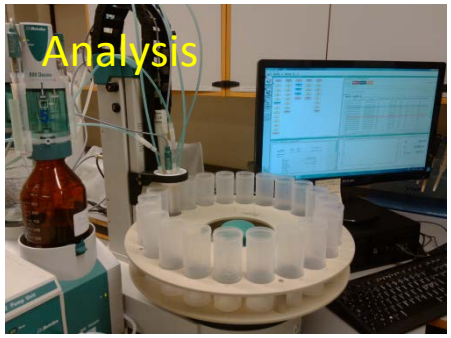


Chloride ingress

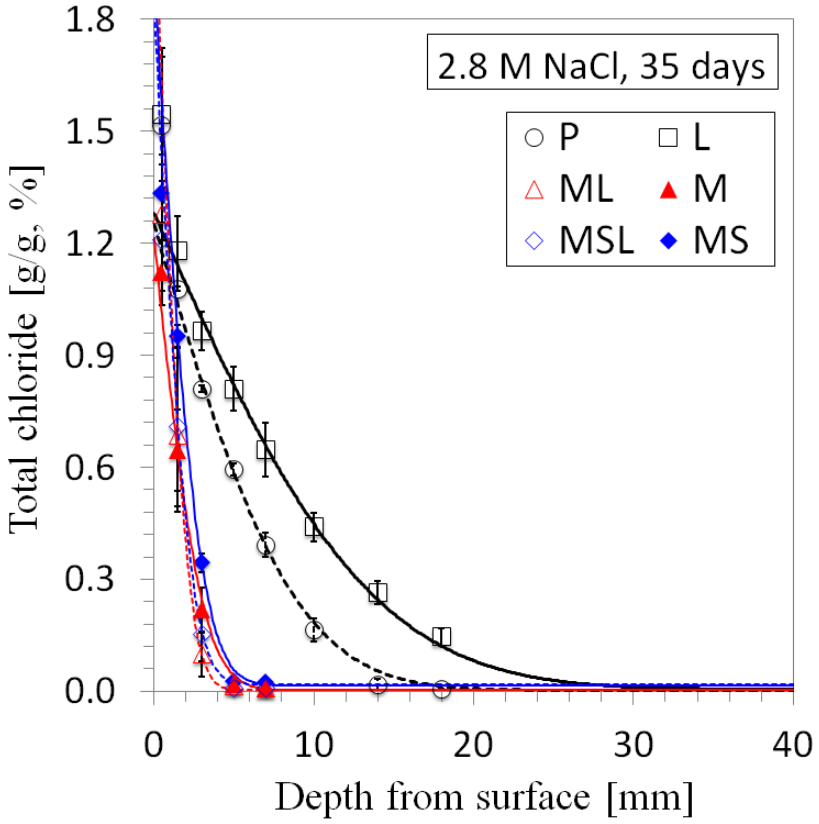


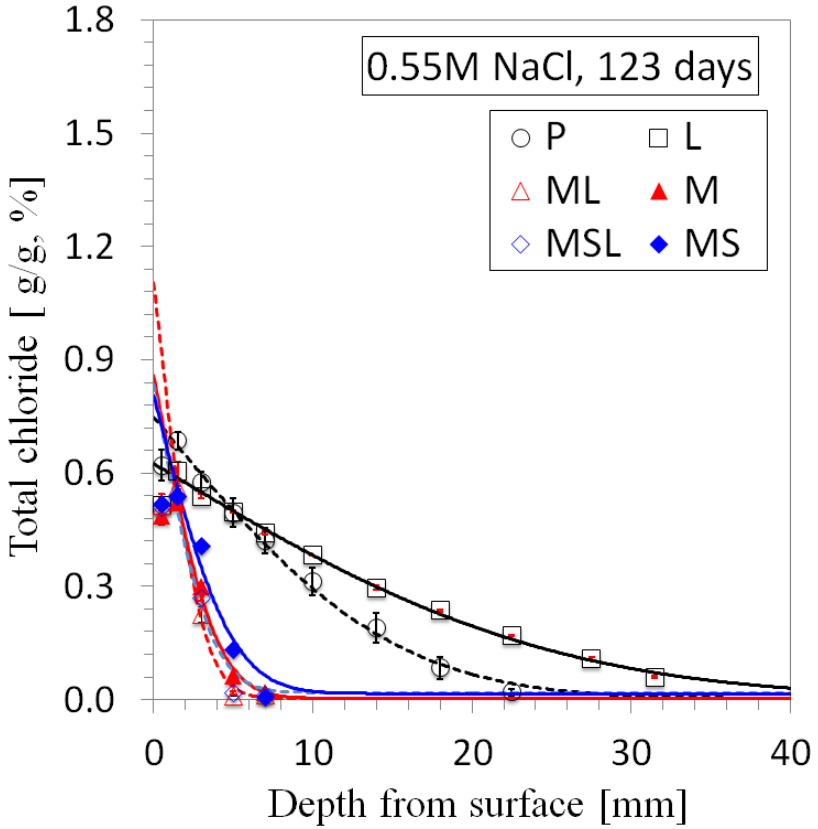




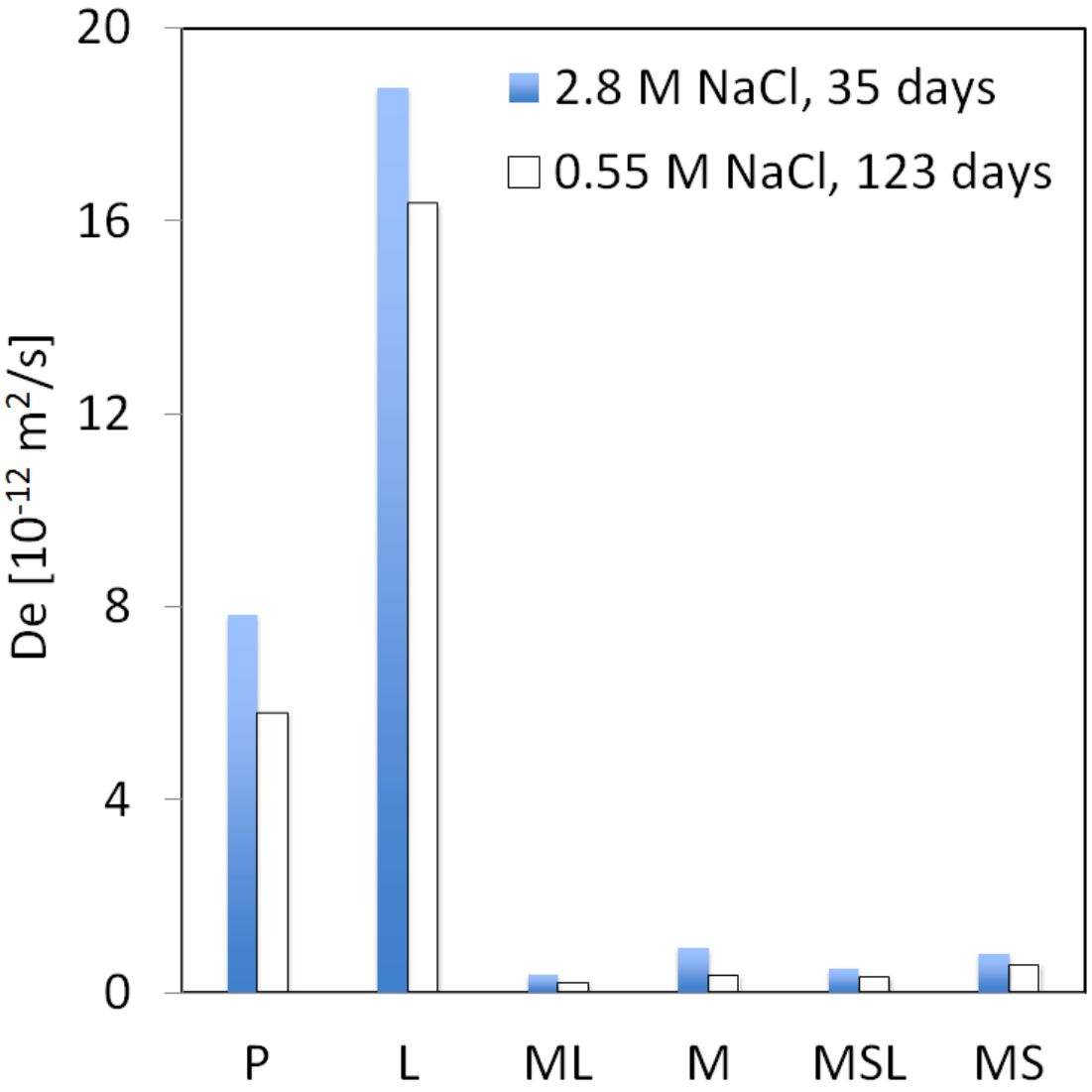


Total chloride profiles





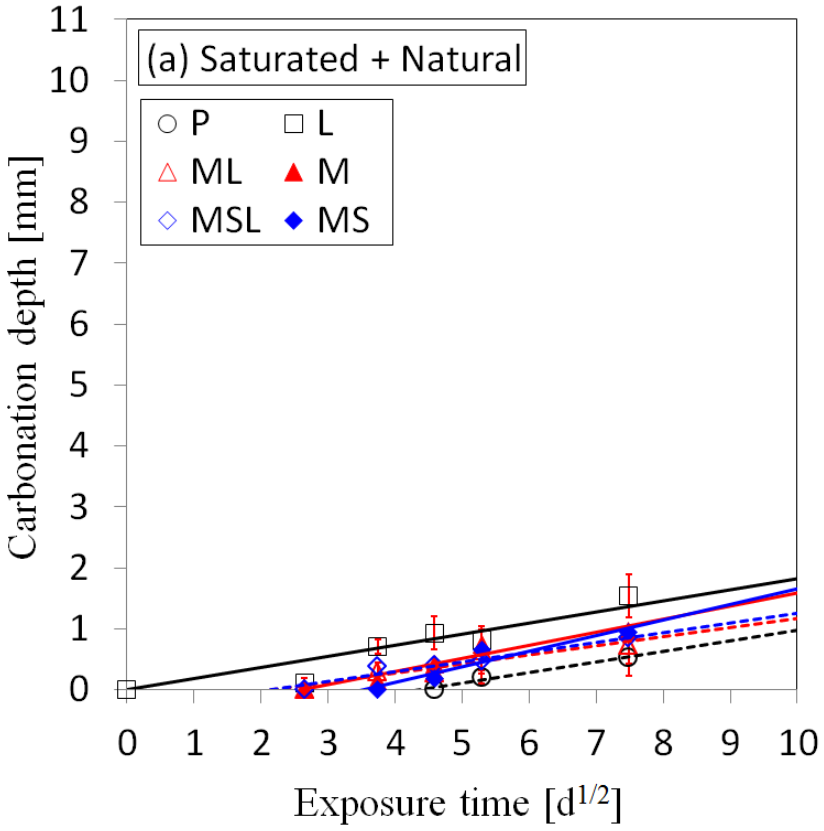
Chloride diffusion coefficients

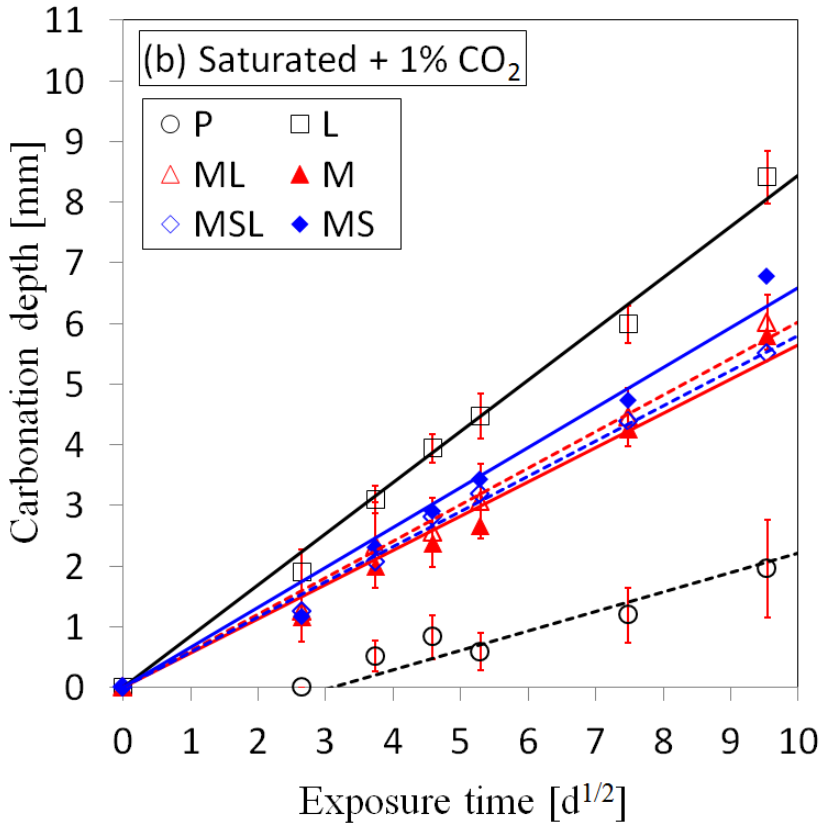


Carbonation

Apparent carbonation depths

Cured saturated for 91 days + 91 days carbonation at RH 57%





Conclusions

- L mortar exhibtis lowest performance in all the durability tests.
- P mortar shows poor resistance to sulfate attack and chloride ingress, but highest resistance to carbonation.
- MK mortars have the highest chloride and sulfate resistance, but a poor resistance towards carbonation.
- Performance with respect to chloride ingress and sulfate attack can be described as a physical effect, where pore connectivity is more important for the durability than the total porosity for MK mortars.
- Presence of portlandite has a major impact on the carbonation, explains why the MK mortars showed poor carbonation resistance

Acknowledgement

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