Effect of quartz and nanosilica on the hydration of LC^3 cement

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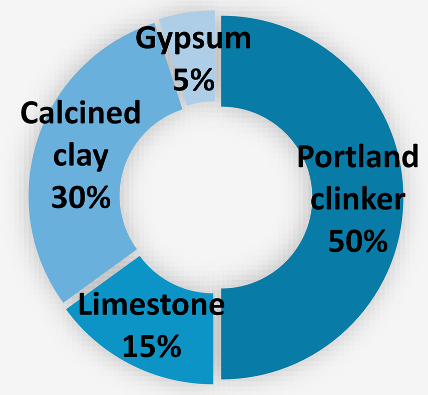
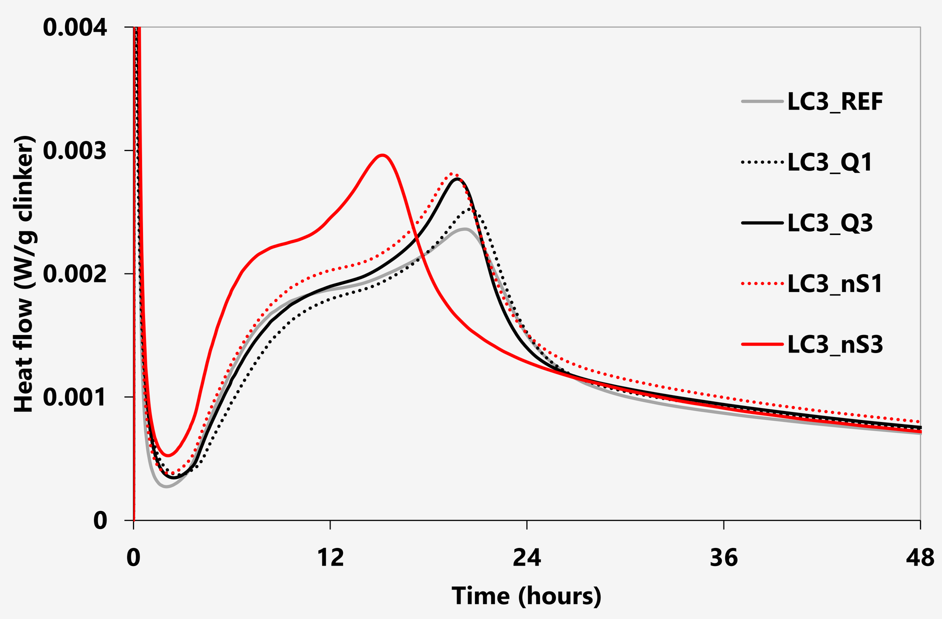
Limestone calcined clay cement LC^3 and its challenges

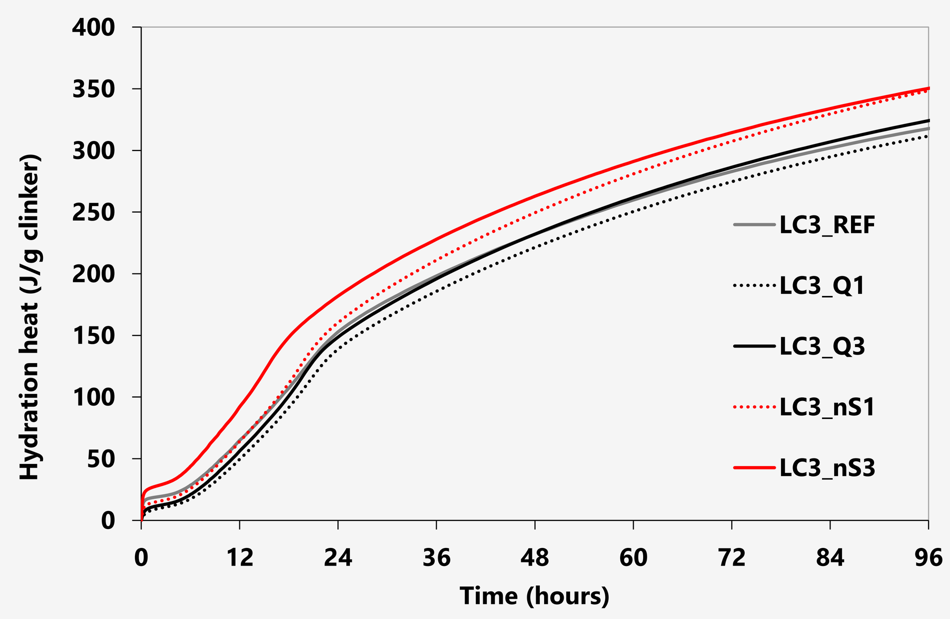
- lower clinker content than Ordinary Portland Cement (OPC) = lower CO_2 emissions
- but also: slower gain of strength = slower construction
- calcined clay – kaolin or a mixed clay? Affordable, accessible.
- optimization of LC^3 composition towards higher rate of hydration (faster setting, strength growth)
- potential hydration accelerators: inorganic and organic salts, alkanolamines, aluminates, nucleation seeds…

Basic LC^3 cement



I. Isothermal (20 °C) calorimetry in LC^3 systems



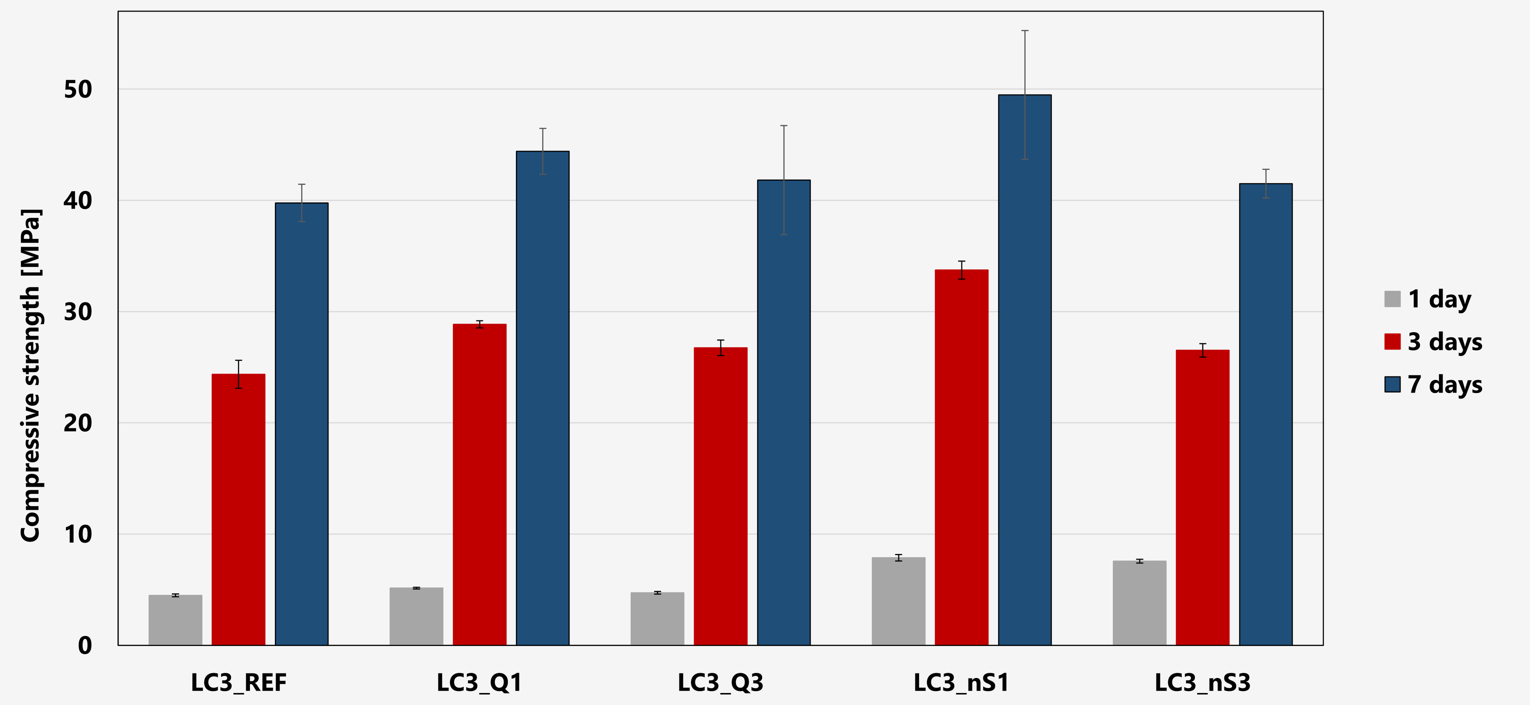


- isothermal calorimetry – simple tool for study of hydration process in cements
- „main hydration peak" involves alite C_3S hydration
- **quartz Q** (d_{50} 28 μm, the same as clinker) and **nanosilica nS** were tested as hydration accelerators
- both additives enhanced main hydration peak, nS3 (3% of nS per clinker) indicated the best performance

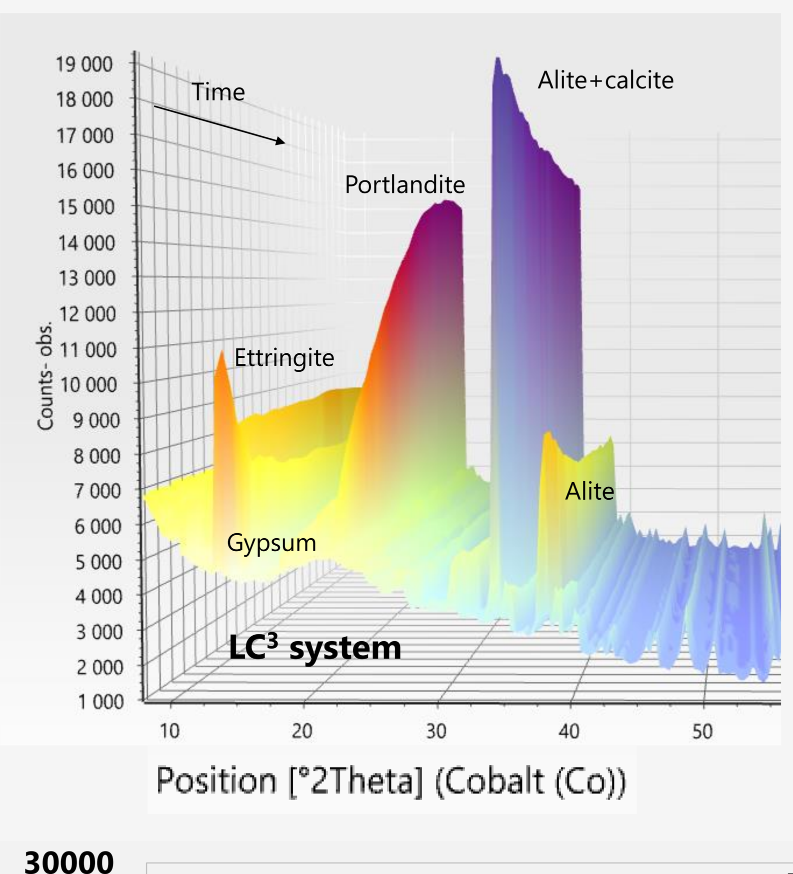
II. Mechanical testing

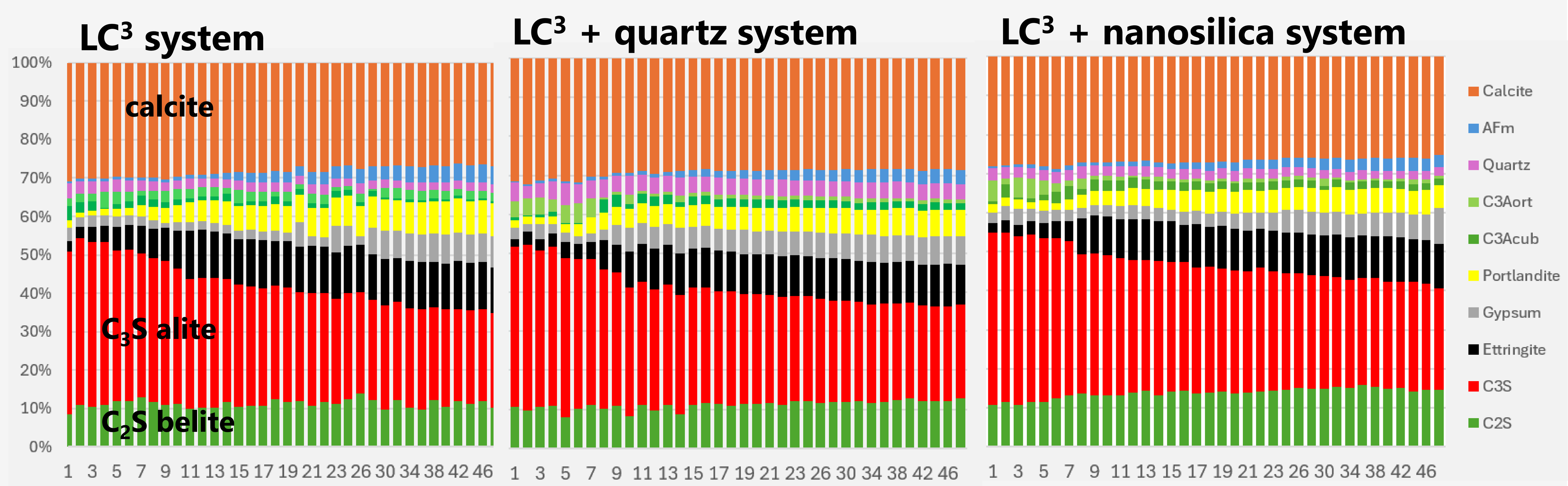
- the acceleration performance was further tested by means of compressive strength of LC^3 cement pastes with additives
- in this test, the best performance was reached by 1% of nanosilica where 1-day strength was almost double compared to reference system

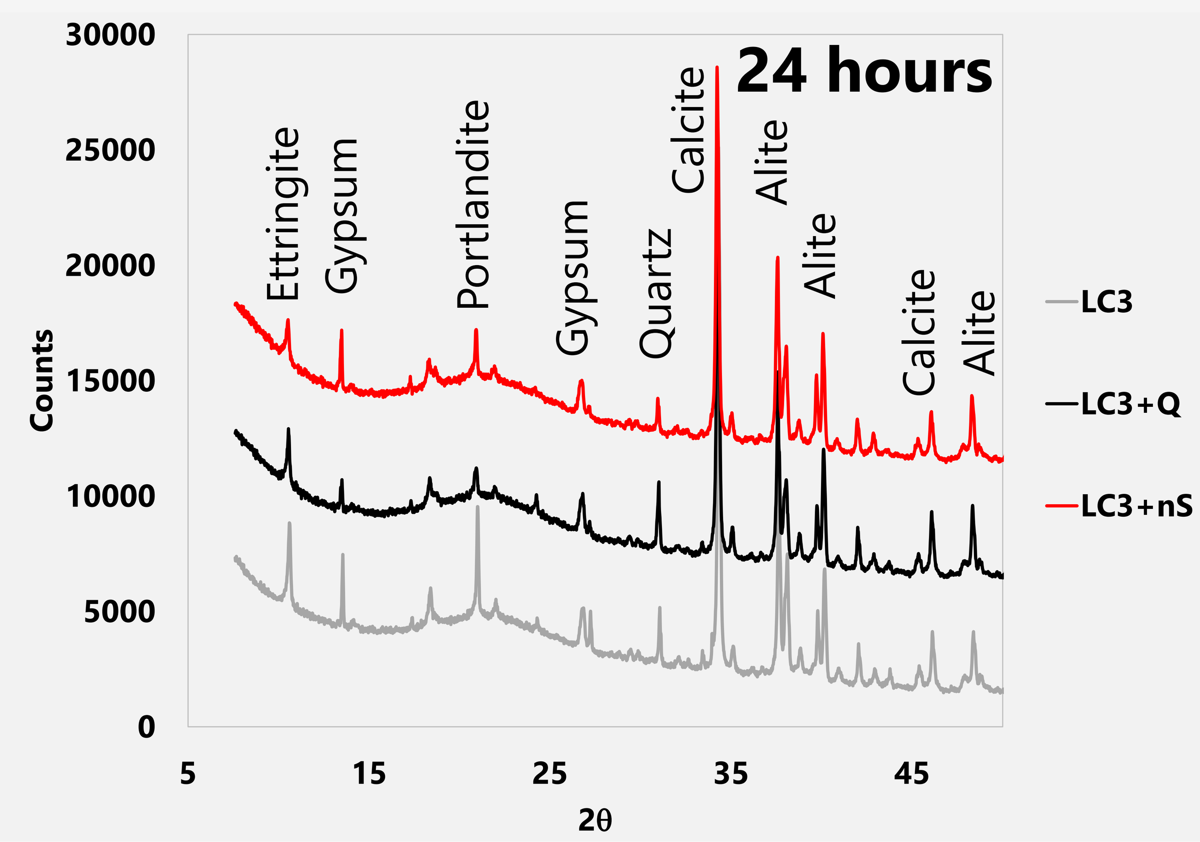
Mix	Clinker	Gypsum	Metakaolin	Calcite	Quartz/nanosilica	Water	Plasticizer
LC3_REF	80	3.2	48	28.8	0	60	2.4
LC3_Q1	80	3.2	48	28.8	0.8	60	2.4
LC3_Q3	80	3.2	48	28.8	2.4	60	2.4
LC3_nS1	80	3.2	48	28.8	0.8	60	2.4
LC3_nS3	80	3.2	48	28.8	2.4	68	2.4



III. In-situ XRD of hydrating pastes, 48 hours







- the hydration course was monitored by in-situ XRD for 48 hours – relative proportion of present crystalline phases was obtained
- **qualitatively**, the SiO_2 additives do not change the process: amorphous C-S-H hydrates, portlandite, ettringite and AFm phases are formed from alite (C_3S) and C_3A
- consumption of portlandite in pozzolanic reaction with nanosilica and fine quartz
- LC^3 + nanosilica system: an unknown trigger of alite and C_3A hydration at 7 hours
- lower amout of AFm phases is formed in quartz and nanosilica systems

IV. Conclusions and perpectives

- nanosilica is very effective hydration accelerator in LC^3 cements
- enhanced formation of C-S-H hydates must be confirmed by thermal analysis
- what is the role of calcite?

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