The evaluation of magnesia characteristics on the mechanical properties of magnesia-silica fume pastes

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Introduction

The incorporation of magnesium oxide in cementitious materials reduces cement demand, which consequently leads to carbon dioxide emissions reduction. Magnesium oxide can react with siliceous materials and produce magnesium silicate hydrate (MSH) compounds that develop significant mechanical properties at 28 days.

Objective

Assess the influence of caustic magnesia powders characteristics on the properties of MSH pastes

Methodology

7 Different pastes were evaluated by:

- Compressive strength (7, 14, 28, and 90 days)
- Thermogravimetric analysis (TGA)
- X-ray diffraction (XRD)
- Attenuated Total Reflectance (ATR)

Materials

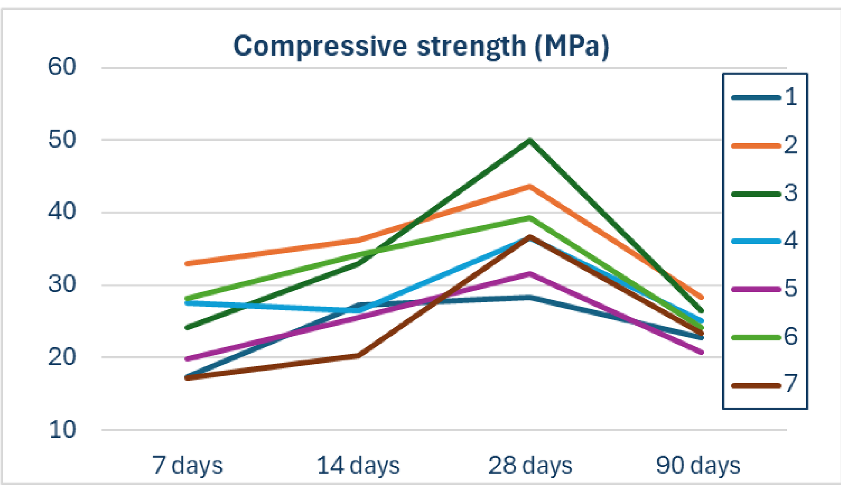
- 7 caustic calcined magnesia (CCM) powders
- Silica fume
- Superplasticizer
- W/S=0,3-0,4

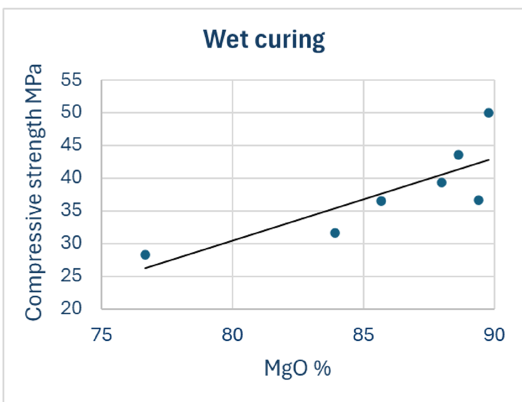
Table 1. Properties of CCMs

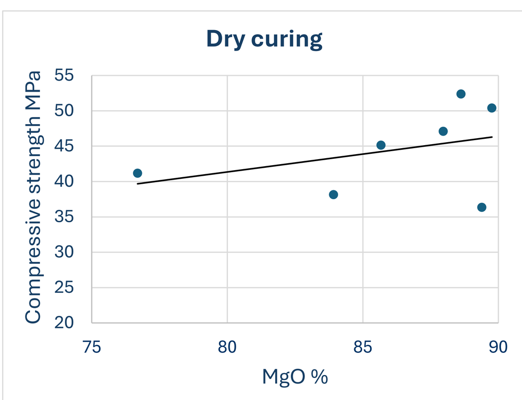
CCM No	1	2	3	4	5	6	7
MgO (%)	76,7	88,6	89,8	85,7	83,9	88,0	89,4
Citric acid activity (sec)	171	197	76	98	71	84	115
Specific surface area (m^2/g)	11	18	15	16	19	22	20
Pasticle size distribution							
d50 (μm)	15	16	16	16	20	30	31
d90 (μm)	86	62	40	60	58	70	72
>75μm (%)	4,20	1,50	0,01	1,1	0,9	2,7	4,9

Results

1. Compressive strength (CS)

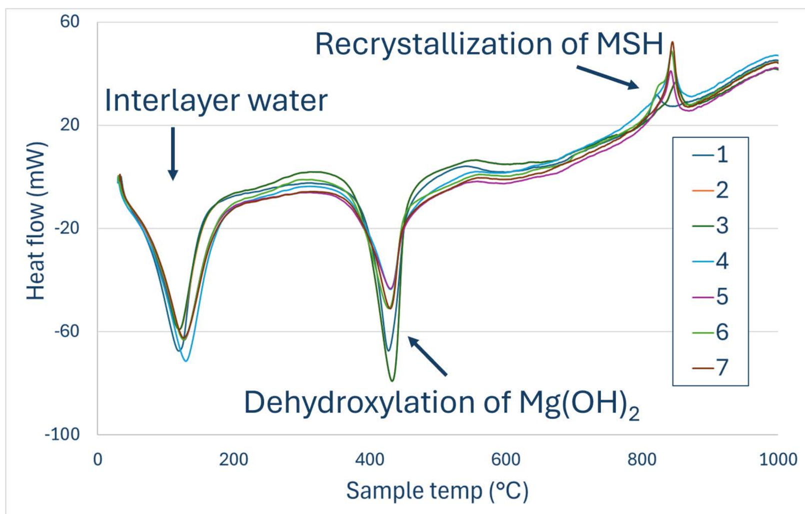


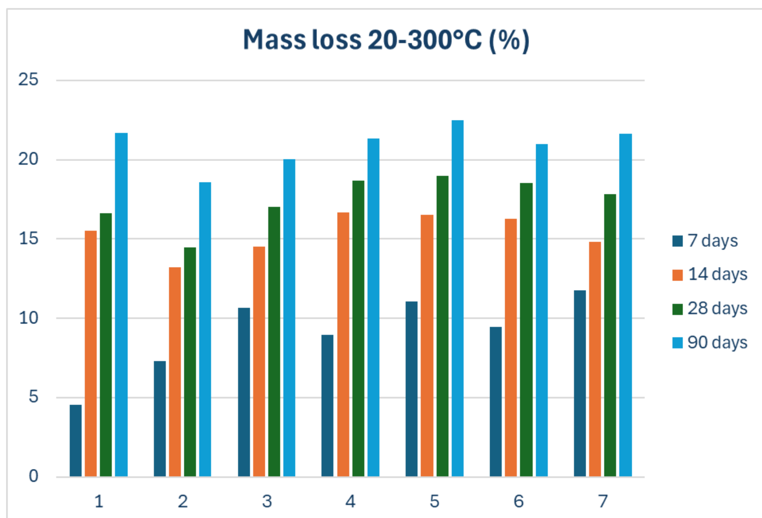




- ➢ Increased at 28 days
- ➢ Decreased at 90 days
- ➢ MgO content affects CS
- ➢ Dry curing favors CS

2. Thermogravimetric analysis



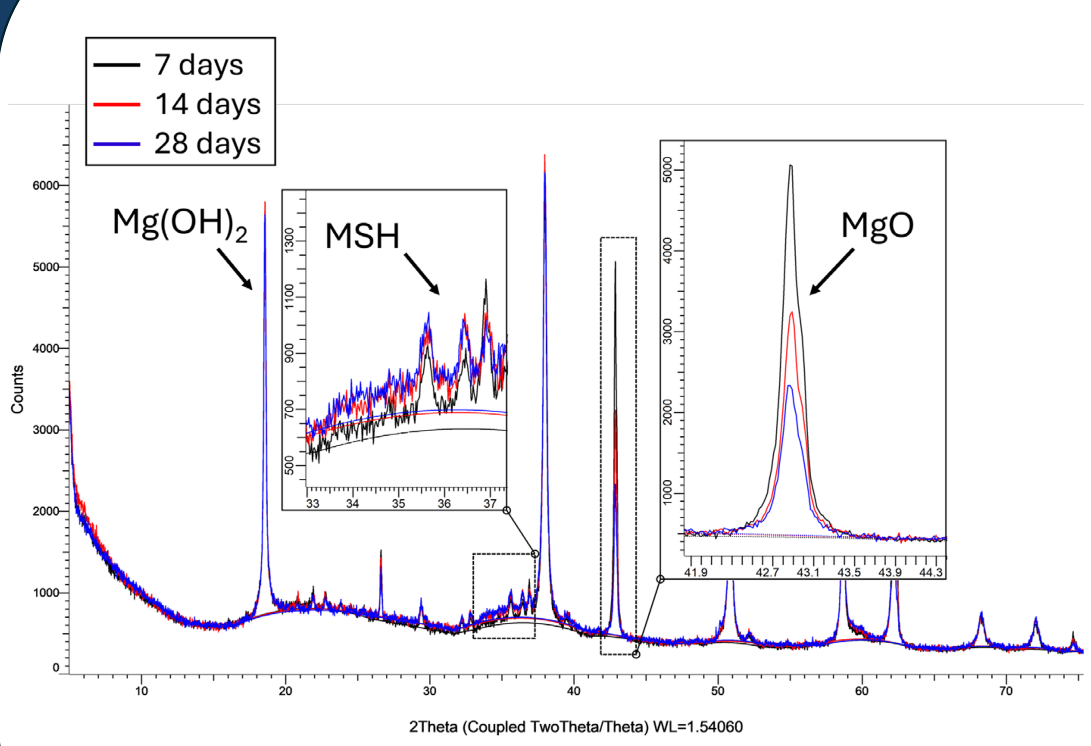


Exothermic peak @ 850°C 28d → MSH

Mass loss @ 20-300°C increased in all pastes with time → MSH

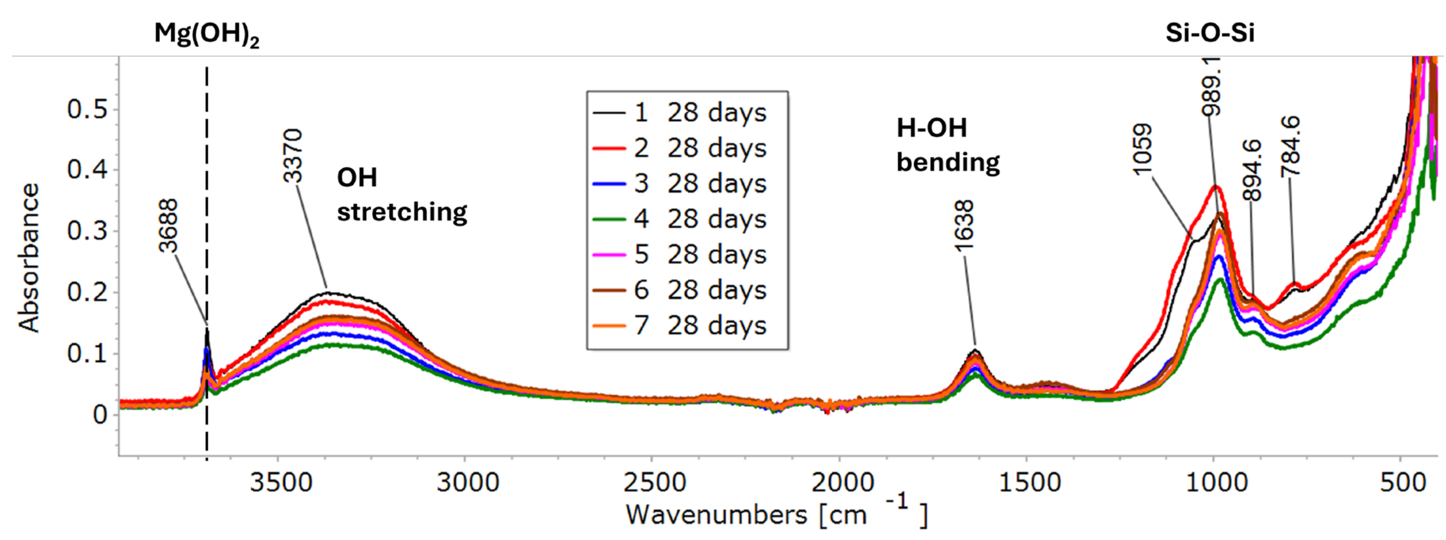
➢ No connection between CCMs' properties and mass loss or heat transfer

3. X-ray Diffraction



- ➢ Periclase (MgO) consumption in time
- ➢ Brucite peaks ($Mg(OH)_2$) remained stable (agreement with TGA results)
- ➢ MSH phase formation between 34° and 37°

4. Attenuated Total Reflectance



1059 & 784 cm^{-1}: anti-symmetric & symmetric stretching vibration of Si-O-Si was observed in pastes with high acid activity CCM

3370 cm^{-1}: higher OH-stretching was observed in magnesia powders with high acid activity

Conclusions

- ➢ MgO content and different curing regimes influence the compressive strength evolution over time
- ➢ Specific surface area, and particle size distribution did not affect mechanical properties and mineralogy in this study
- ➢ The potential for MSH formation was similar in all systems
- ➢ MSH formation was identified through Thermogravimetric analysis and X-ray Diffraction analysis

References

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