Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)

Thermodynamics-based simulations of the hydration of low-heat Portland cement and the compensatory effect of magnesium oxide admixtures

Cite this as: Wenwei LI, Yifan ZHOU, Jiajie YIN, Yuxiang PENG, Yushan WANG, Shengwen TANG, Yan SHI, Yang WANG, Lei WANG, 2025. Thermodynamics-based simulations of the hydration of low-heat Portland cement and the compensatory effect of magnesium oxide admixtures. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 26(4):305-319. https://doi.org/10.1631/jzus.A2400521

Introduction

Advantages of low-heat Portland cement (LHP):
low heat of hydration, green and low-carbon

Example: Wudongde Dam



GEMS Modeling

A thermodynamic model was established to simulate the phase of LHP

Chemical oxide constituents (wt.%)	Percentage (%)	Mineral composition (wt.%)	Percentage (%)
CaO	61.86	C_3S	28.7 [b] (30.7) [c]
SiO_2	23.98	C_2S	47.0 [b] (44.3) [c]
Fe_2O_3	4.22	C_3A	4.1 [b] (3.6) [c]
Al_2O_3	4.23	C_4AF	12.8 [b] (14.1) [c]
MgO	2.89	Gypsum	3.9
SO_3	2.31		
R_2O [a]	0.31		
Loss on ignition (wt.%)	0.45		

Notes: [a] Alkali content (R_2O) = Na_2O + 0.658K_2O; [b] From Bogue analysis; [c] From X-ray analysis

Fig. 1. LHP cement composition reference

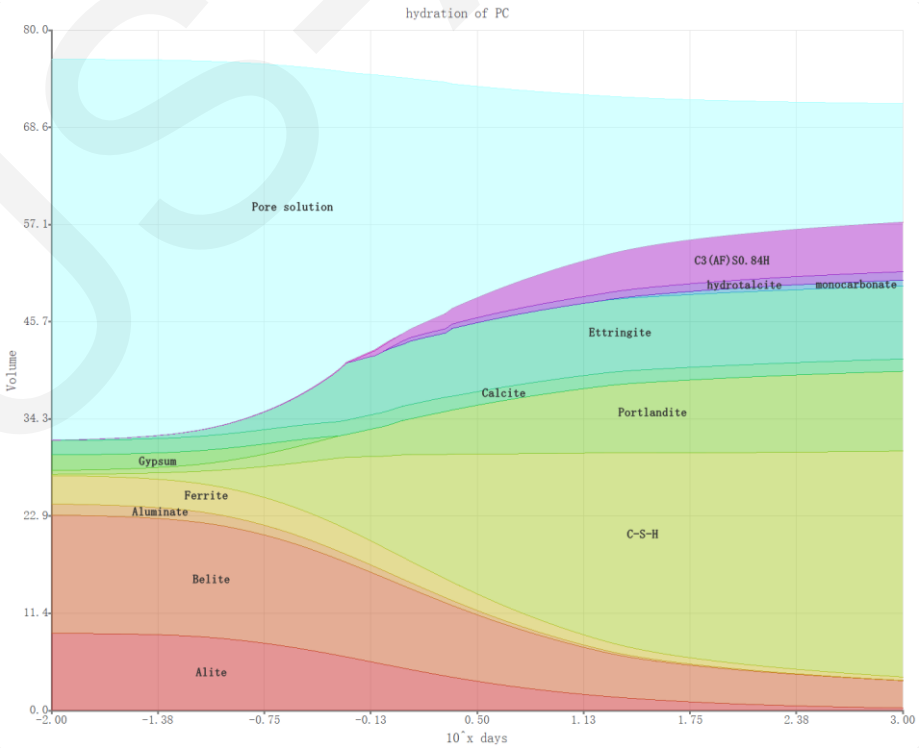

Fig. 2. WC04T20M4

Hydration Modeling

- **MATLAB modeling, disc filling method**

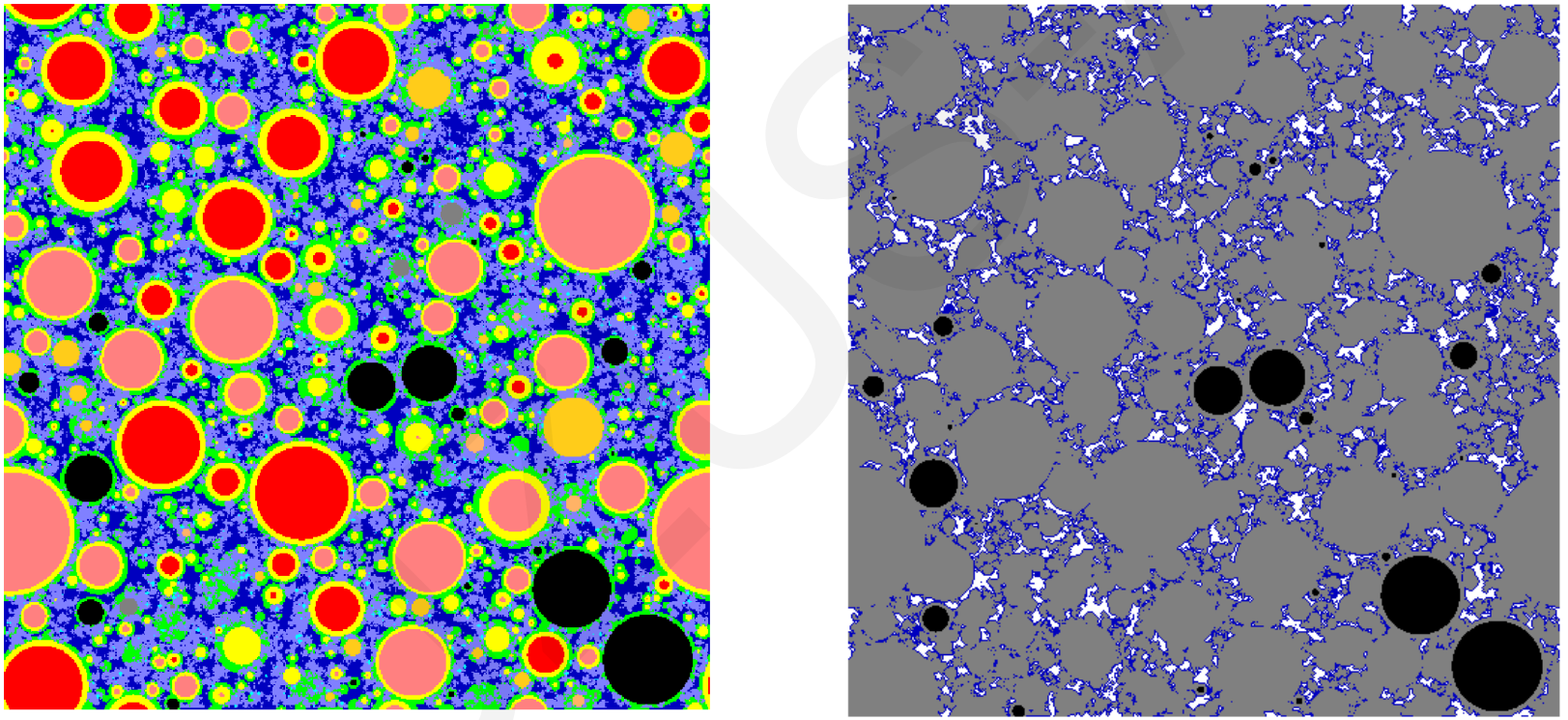

Fig. 3. WC04T20M4 1DAY

Volume Shrinkage

- **Compare the porosity after shrinkage**

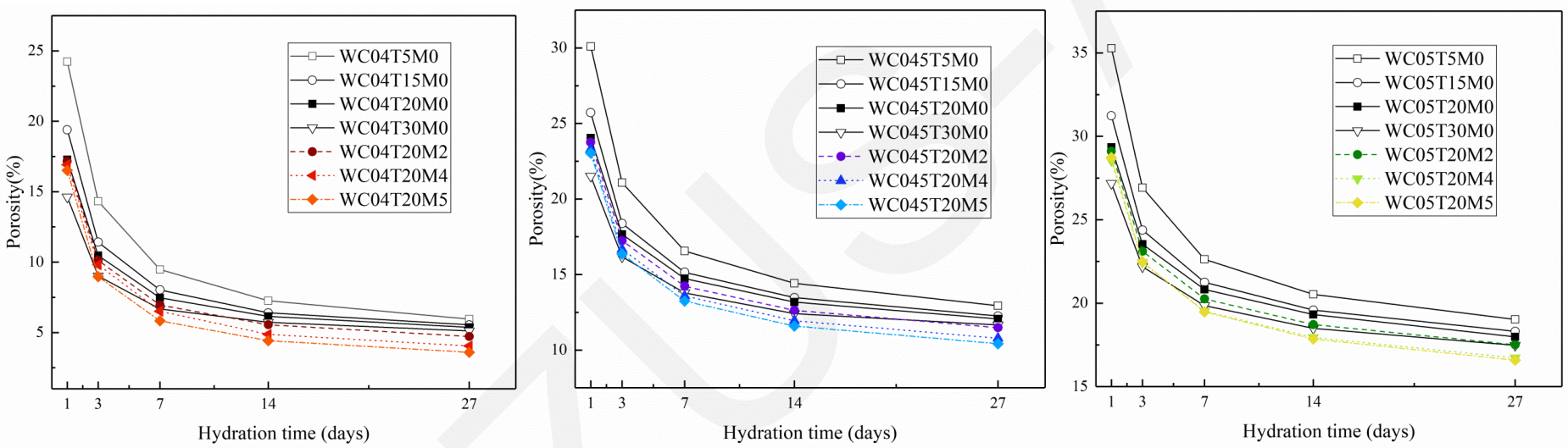

Fig. 4. Shrinkage results of LHP cement under different conditions

Conclusions

- The larger the water-cement ratio, the smaller the autogenous shrinkage of the cement paste. With the increase of hydration time, MgO continuously hydrates, and its influence on the autogenous shrinkage continuously grows. When the content of MgO was 4wt%, the shrinkage compensation effect is found to be the best.This study provides valuable insights for the use of low-heat Portland cement, and future work may extend the analysis to other types of cement.

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