

# Optimal slag content for geopolymer composites under freeze-thaw cycles with different freezing temperatures

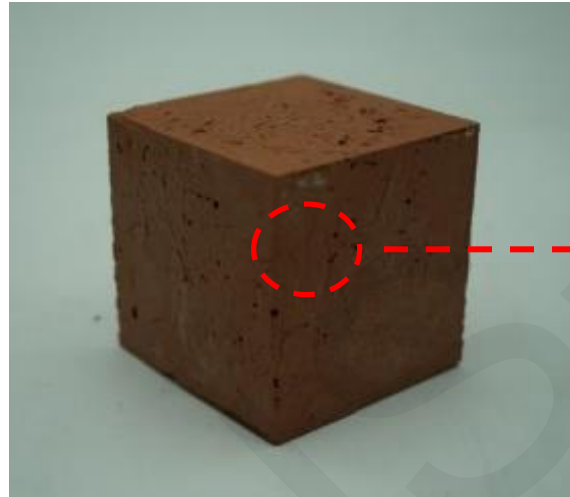
Lifeng FAN, Weiliang ZHONG, Guang WANG, Yan XI

Cite this as: Lifeng FAN, Weiliang ZHONG, Guang WANG, Yan XI, 2023. Optimal slag content for geopolymer composites under freeze-thaw cycles with different freezing temperatures. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 24(4):366-376.

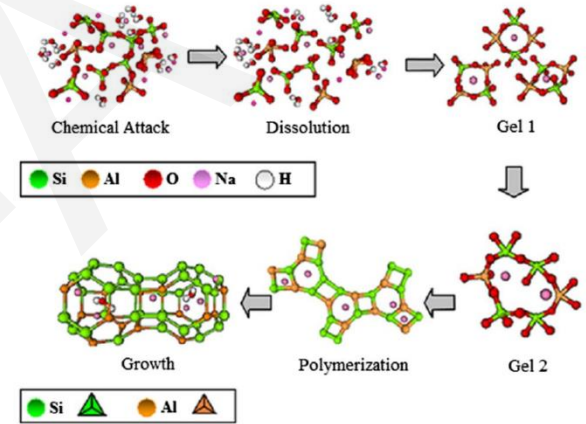
<https://doi.org/10.1631/jzus.A2200437>

# Introduction

- ◆ Low CO<sub>2</sub> emission
- ◆ Available raw material
- ◆ High mechanical properties



Geopolymer



Geopolymerization



Global Change Institute building



Brisbane West Wellcamp airport

# Introduction



**Freeze-thaw cycles**



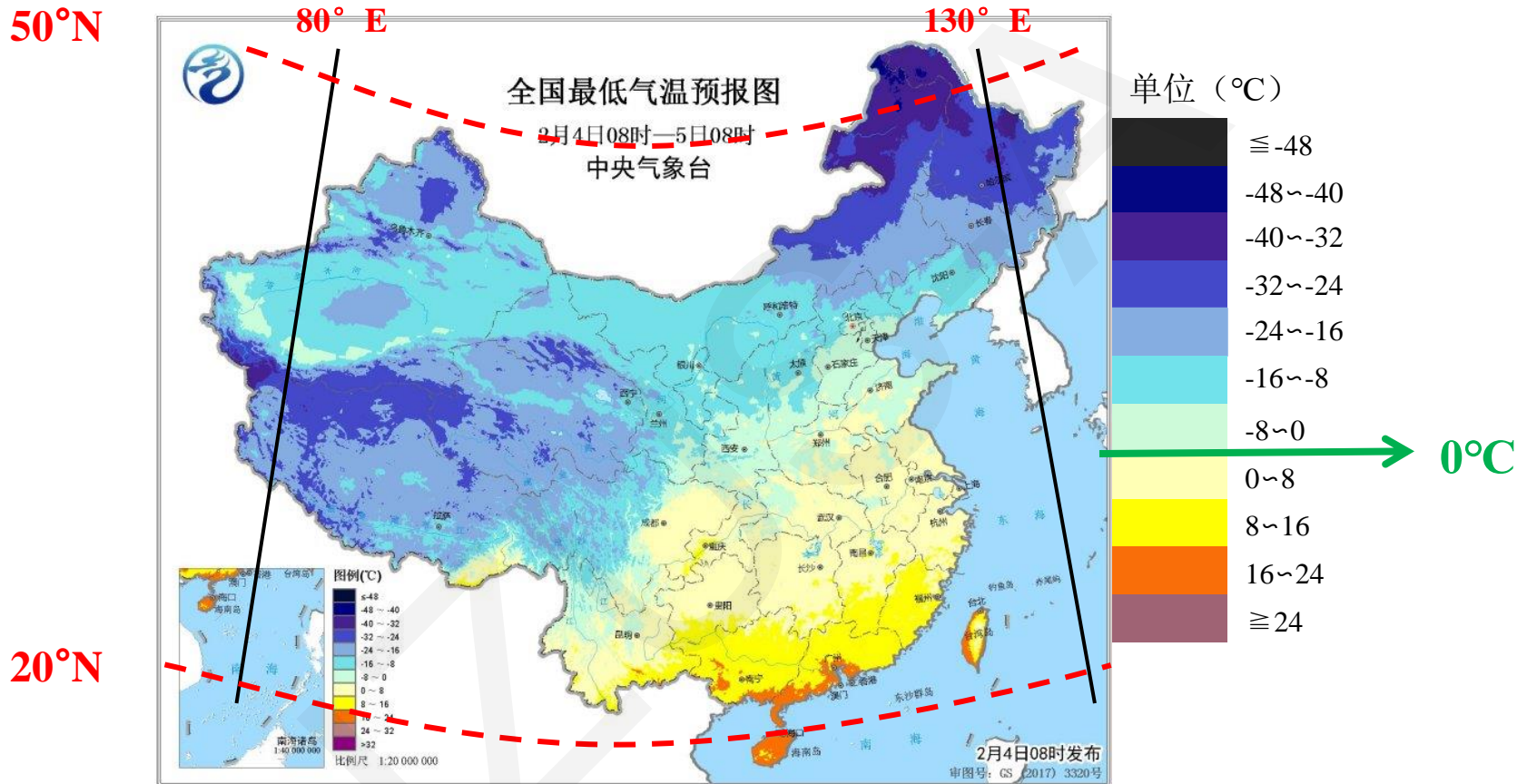
**Cracking mechanism of F-T cycles**



**Cracking and degradation**

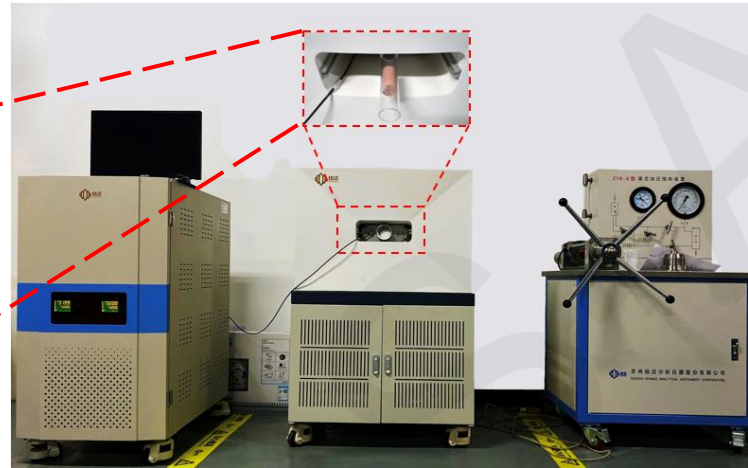
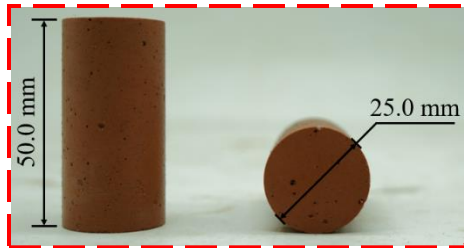
**In order to ensure the durability of geopolymer in cold environments, it is important to further study its F-T resistance.**

# Introduction



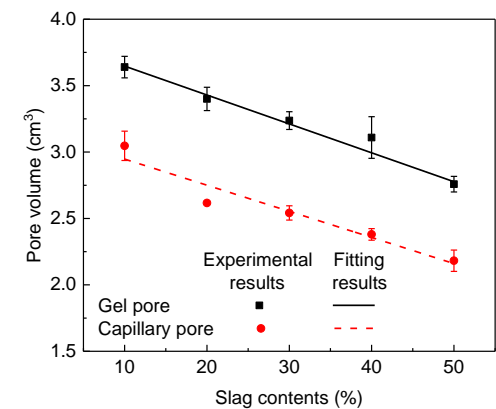
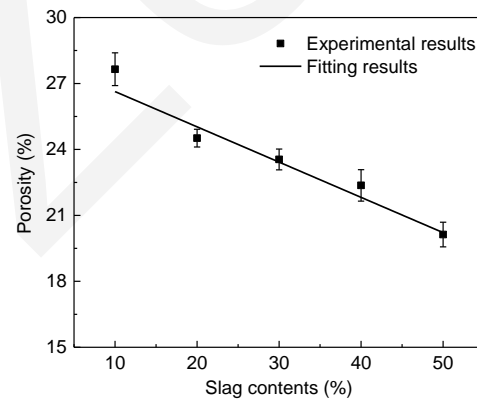
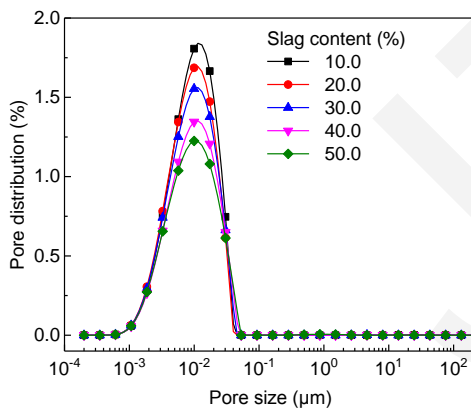
- ◆ The F-T resistance of geopolymer at different **freezing temperatures** is still unclear
- ◆ **Improving the F-T durability** of geopolymer in cold regions needs further study

# Results and discussion



- ◆ Nondestructive
- ◆ Quantitative
- ◆ Accurate

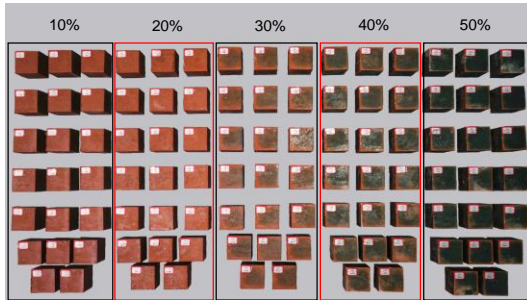
## Low-field nuclear magnetic resonance



## Pore structure characteristics analysis

# Results and discussion

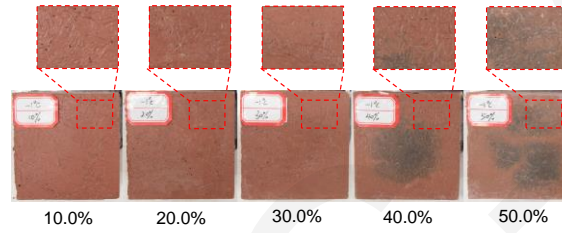
## F-T cycles treatment



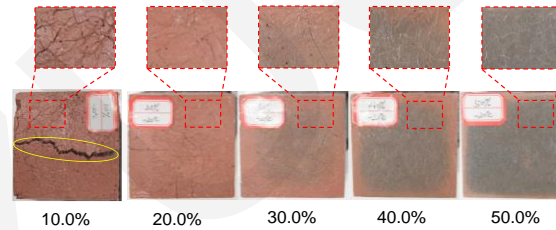
F-T  
cycles



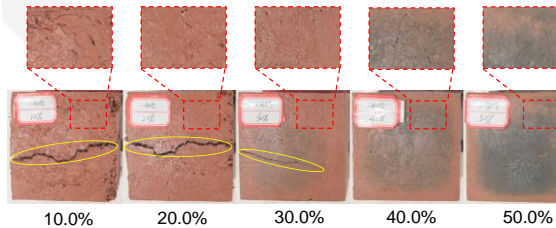
## Surface appearance



Freezing temperatures:  $-1.0\text{ }^{\circ}\text{C}$

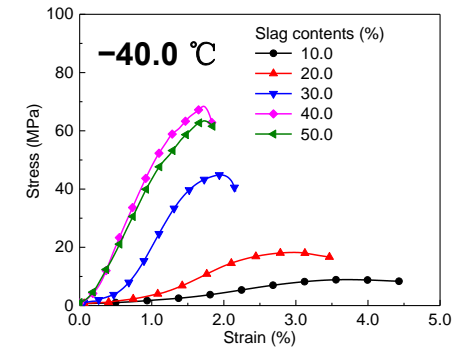
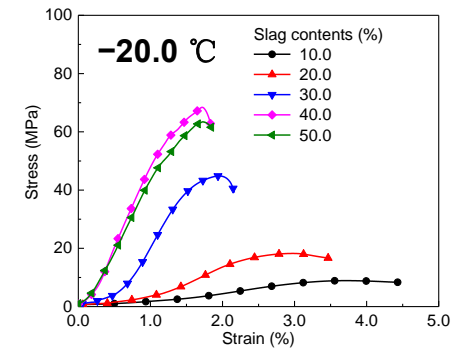
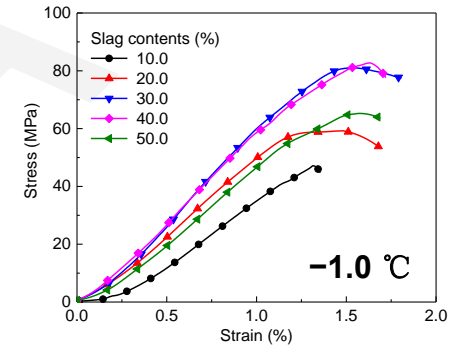


Freezing temperatures:  $-20.0\text{ }^{\circ}\text{C}$

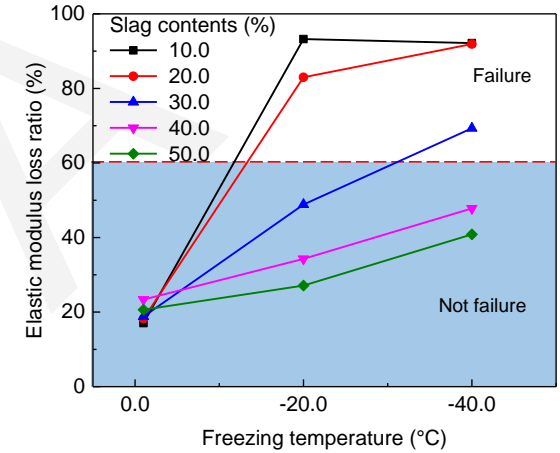
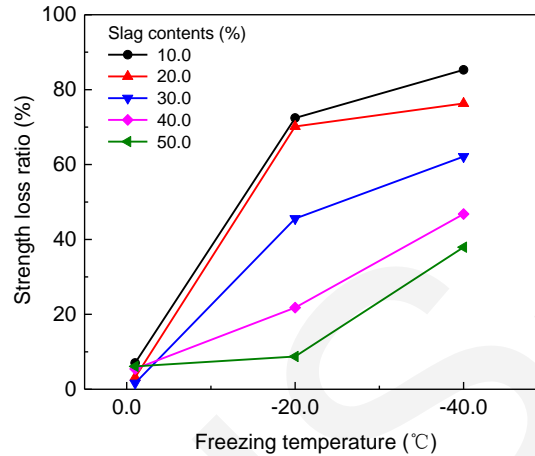
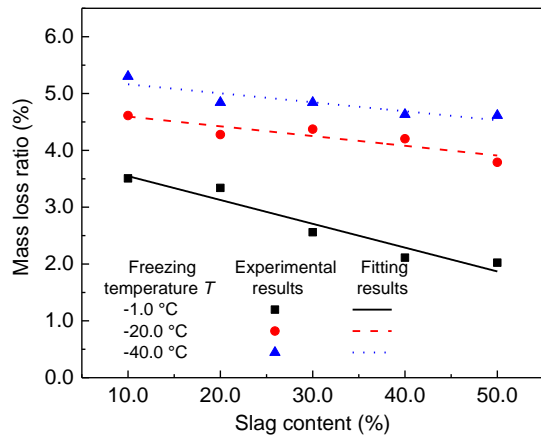


Freezing temperatures:  $-40.0\text{ }^{\circ}\text{C}$

## Mechanical properties



# Results and discussion



## The loss ratio of physical and mechanical properties after F-T cycles

		Slag contents				
		10.0 %	20.0 %	30.0 %	40.0 %	50.0 %
Freezing temperature	-1.0 °C	47.15(4.69)	59.23(5.73)	81.05(7.06)	82.71(6.57)	65.25(5.55)
	-20.0 °C	8.91(0.38)	18.24(1.19)	44.85(4.44)	68.40(5.63)	63.42(5.10)
	-40.0 °C	7.46(0.44)	14.48(0.57)	31.20(2.67)	46.54(4.48)	43.14(4.13)

■ Suggested slag content  $\sigma(E)$ :  $\sigma$  is compressive strength MPa,  $E$  is elastic modulus GPa.

The **suggested slag content** can provide a reference for the application of geopolymer in cold regions.

# Conclusions

- 1. The incorporation of slag can inhibit the cracking of the geopolymer in cold environments and further improve the F-T resistance of geopolymer composites.**
- 2. The F-T damage of geopolymer composites is more serious as the freezing temperature decreases, but the damage degree of the geopolymer composites decreases as slag content increases.**
- 4. The geopolymer composites with 40.0% and 50.0% slag contents still preserve high mechanical properties after F-T cycles with different freezing temperatures.**