Imperial College London

EPSRC DIAMOND Consortium
Nuclear Waste and Decommissioning

An assessment of drying shrinkage in metakaolin-based geopolymers

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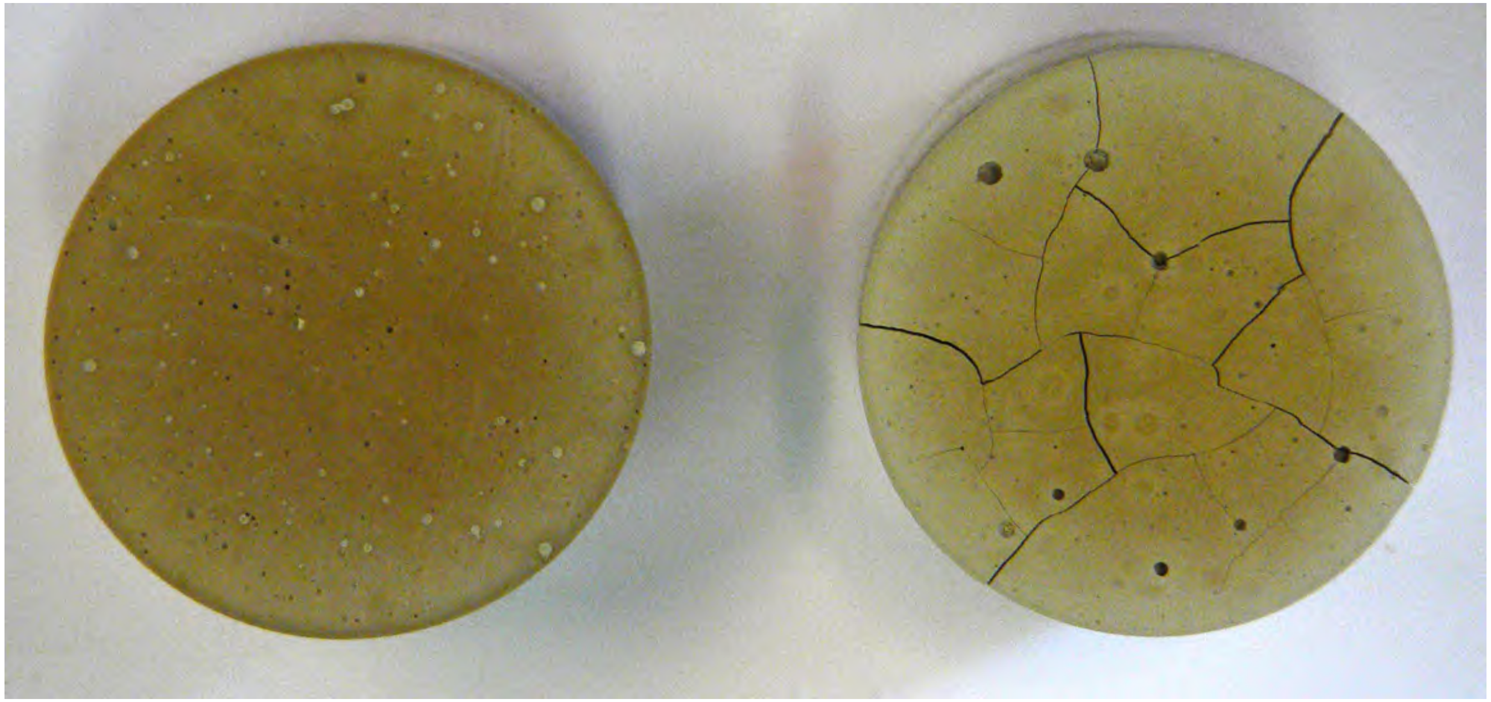
Outline

Problem: Cracking of Geopolymers

Investigation why cracking occurs

Conclusions

Problem: Cracking of Geopolymers



Geopolymers cured over a long time at room temperature, without cover

Experiments

metakaolin, Na_2SiO_3 + NaOH solution was mixed

1 day cured in sealed bags at RT and removed

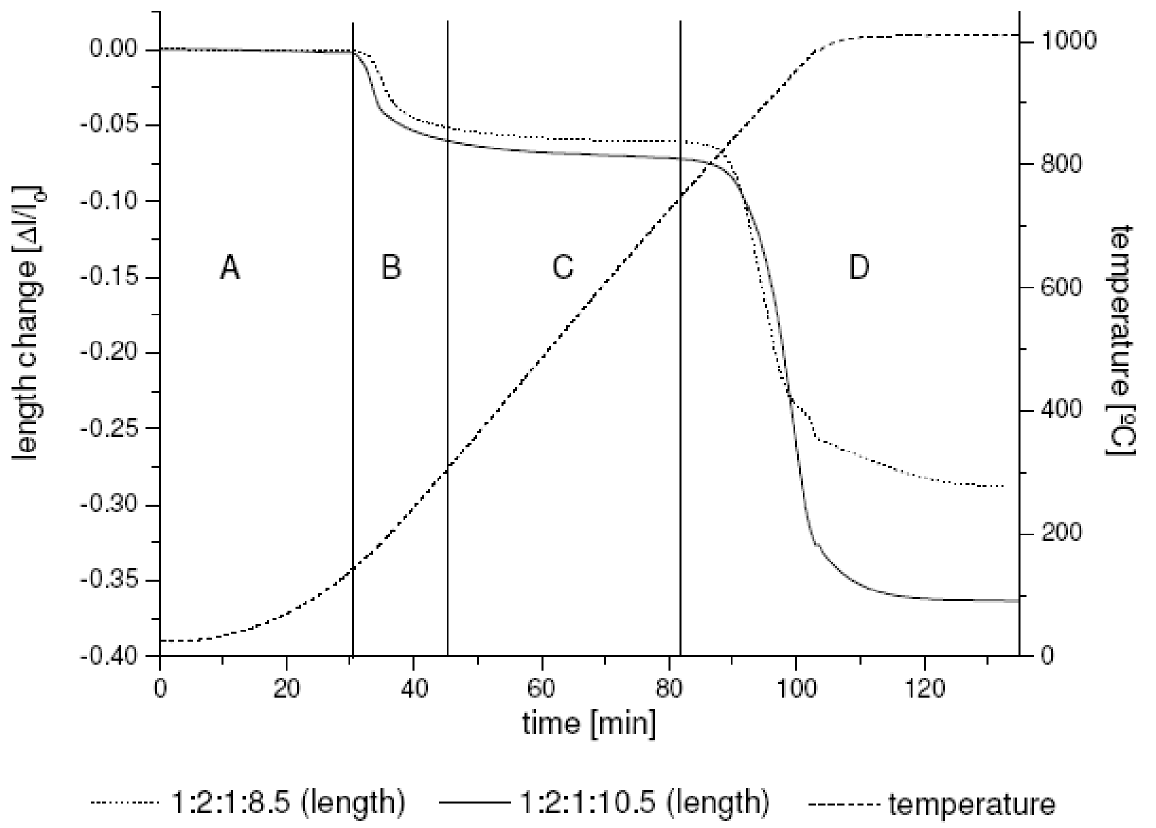
further curing in sealed bags for 56 days

molar ratio was altered

- Al:Si:Na:H_2O 1:2:1:x x= 7.5 to 10.5
- Al:Si:Na:H_2O 1:x:1:8 x= 1.6 to 2.4
- Al:Si:Na:H_2O 1:2:x:8 x= 0.75 to 1.3
- Al:Si:x:H_2O 1:2:1:8 x= Na/K

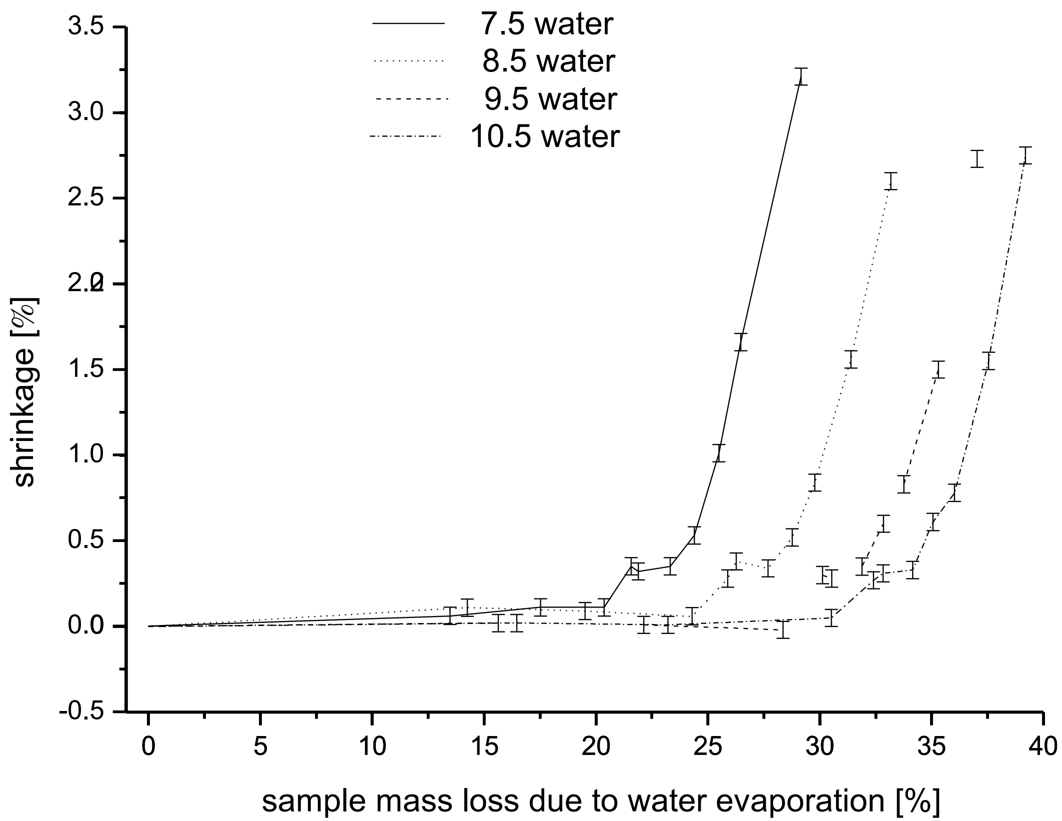
Influence of H_2O on cracking

Dilatometer results



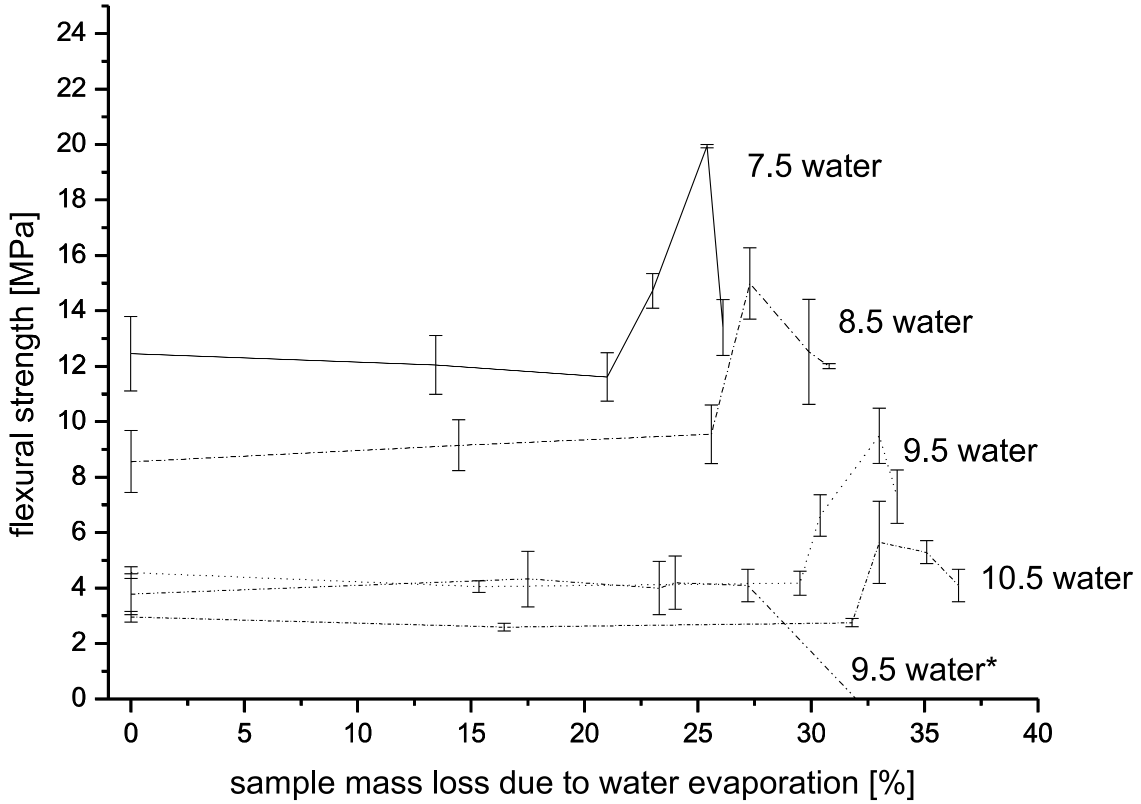
Influence of H_2O on cracking

Shrinkage measured using an extensometer



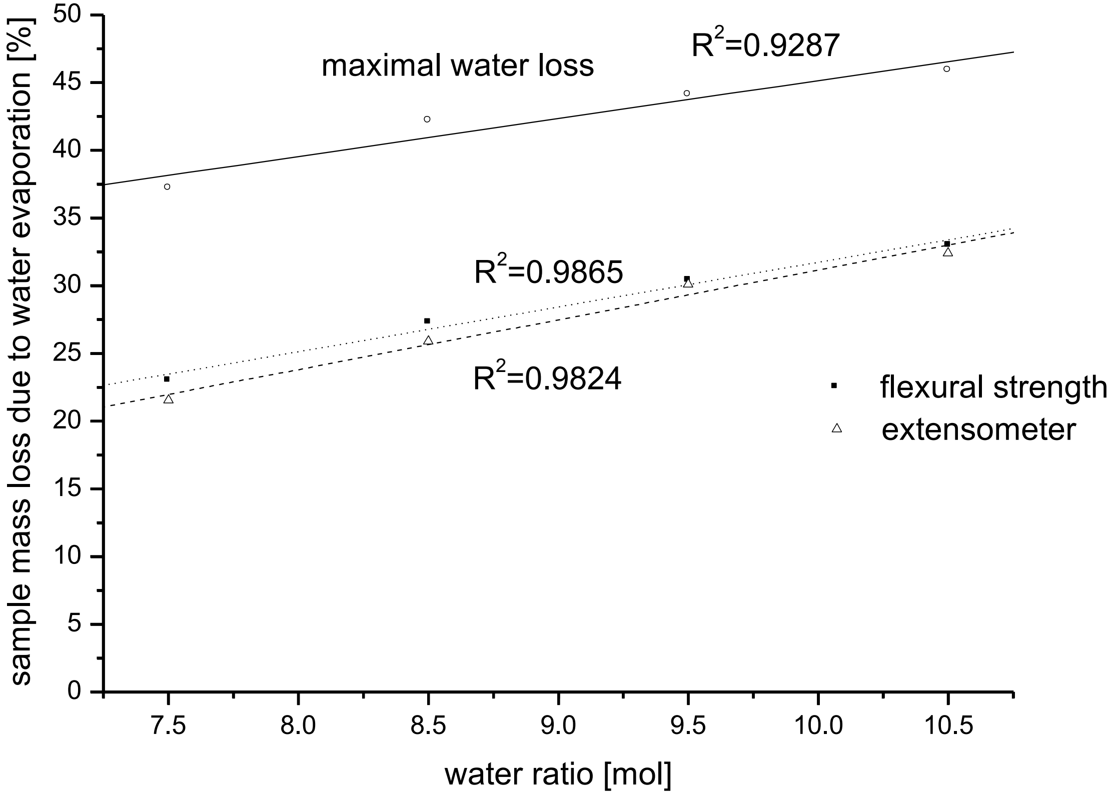
Influence of H_2O on cracking

Flexural strength: 3 point bending test



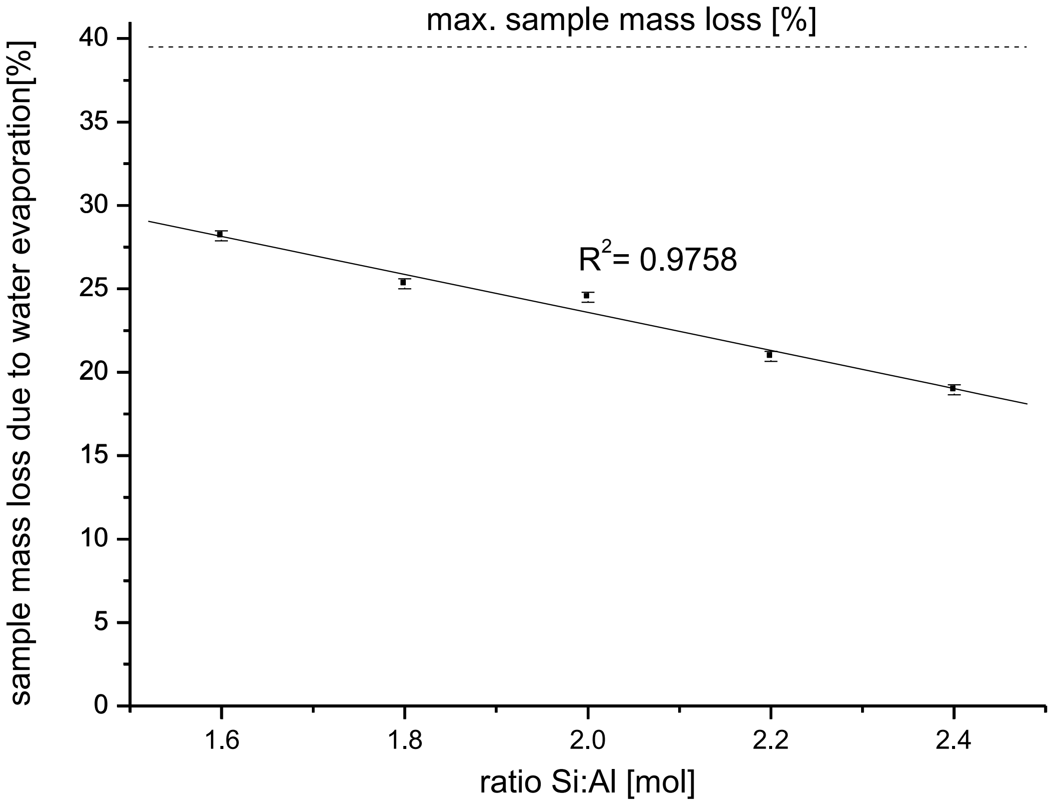
Influence of H_2O on cracking

Shrinkage of Geopolymers



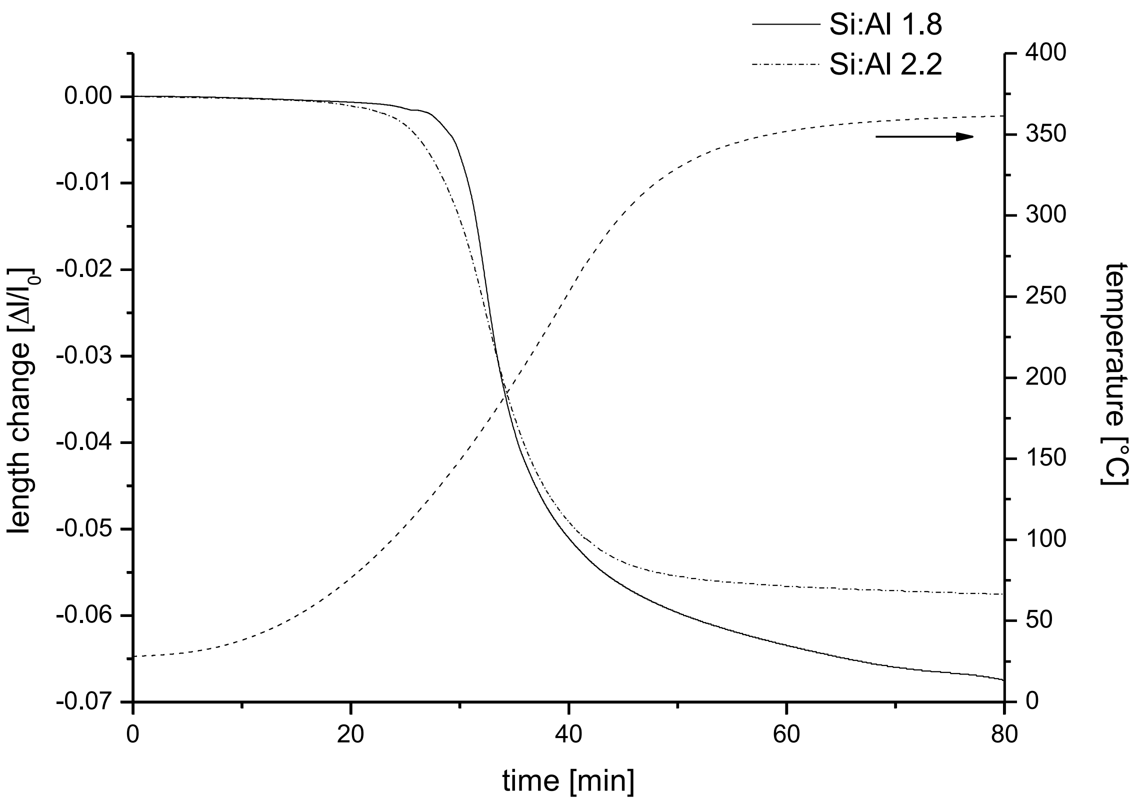
Influence of Si on cracking

Onset point of shrinkage measured using extensometer

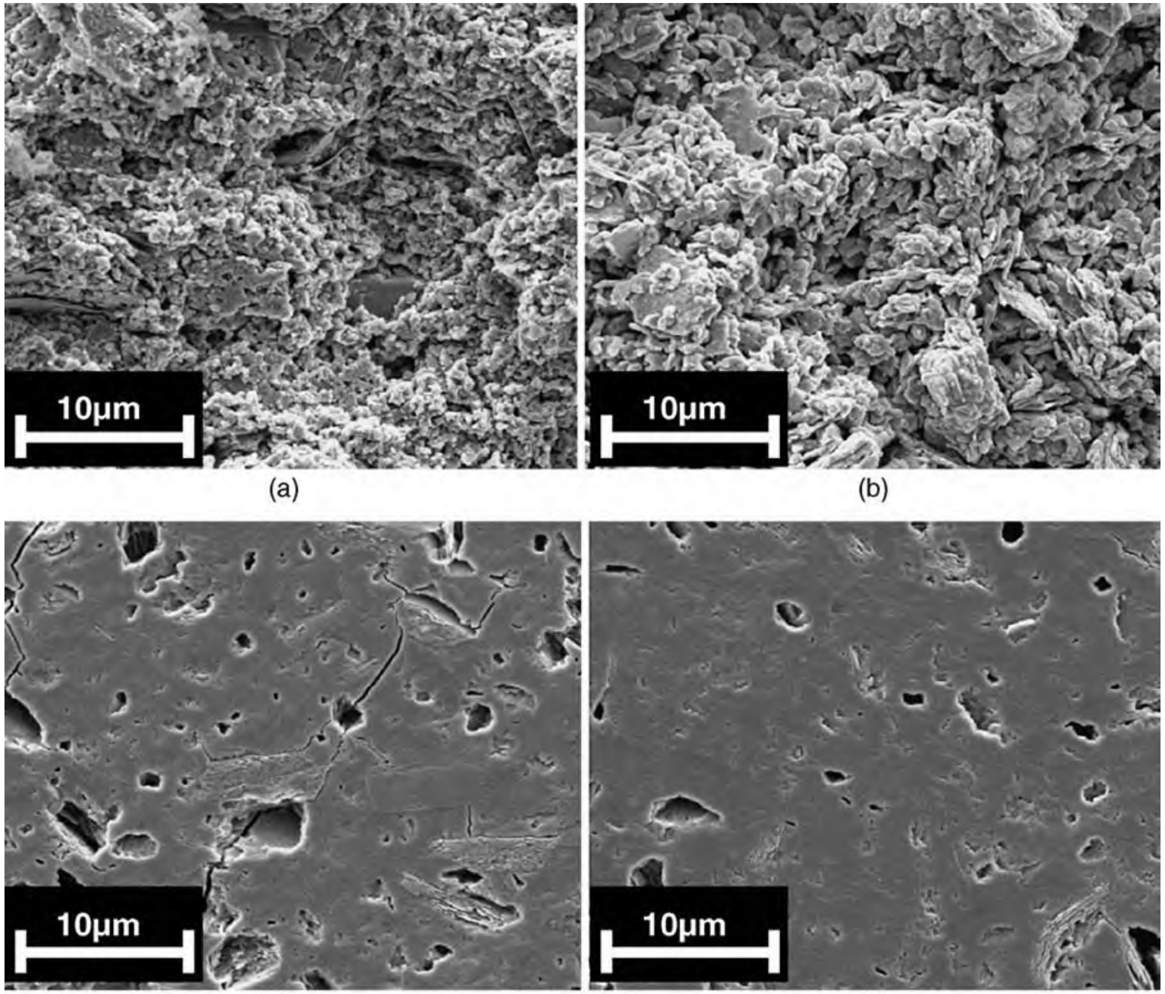


Influence of Si on cracking

Shrinkage during heating determined by dilatometry



Influence of Si on cracking



(a) (b) (c) (d)

a) Si/Al 1.15

b) Si/Al 1.40

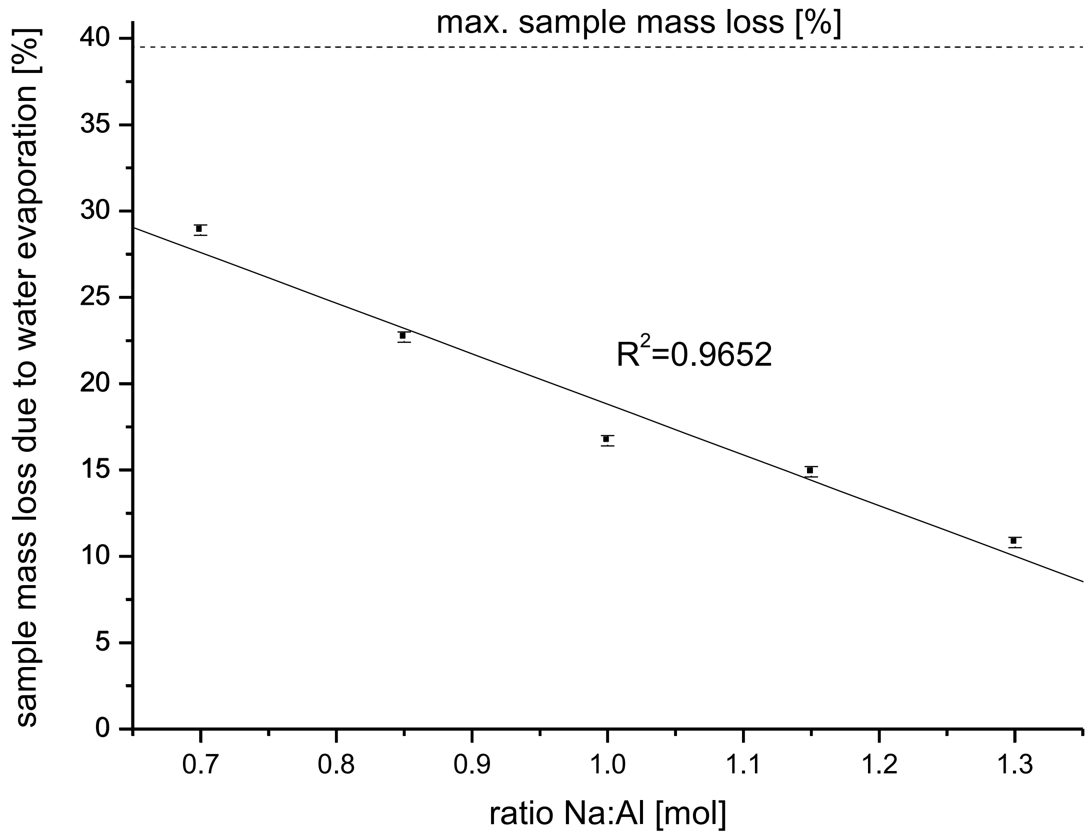
c) Si/Al 1.65

d) Si/Al 1.90

Colloids and Surfaces A: Physicochem. Eng. Aspects 269 (2005) 47–58

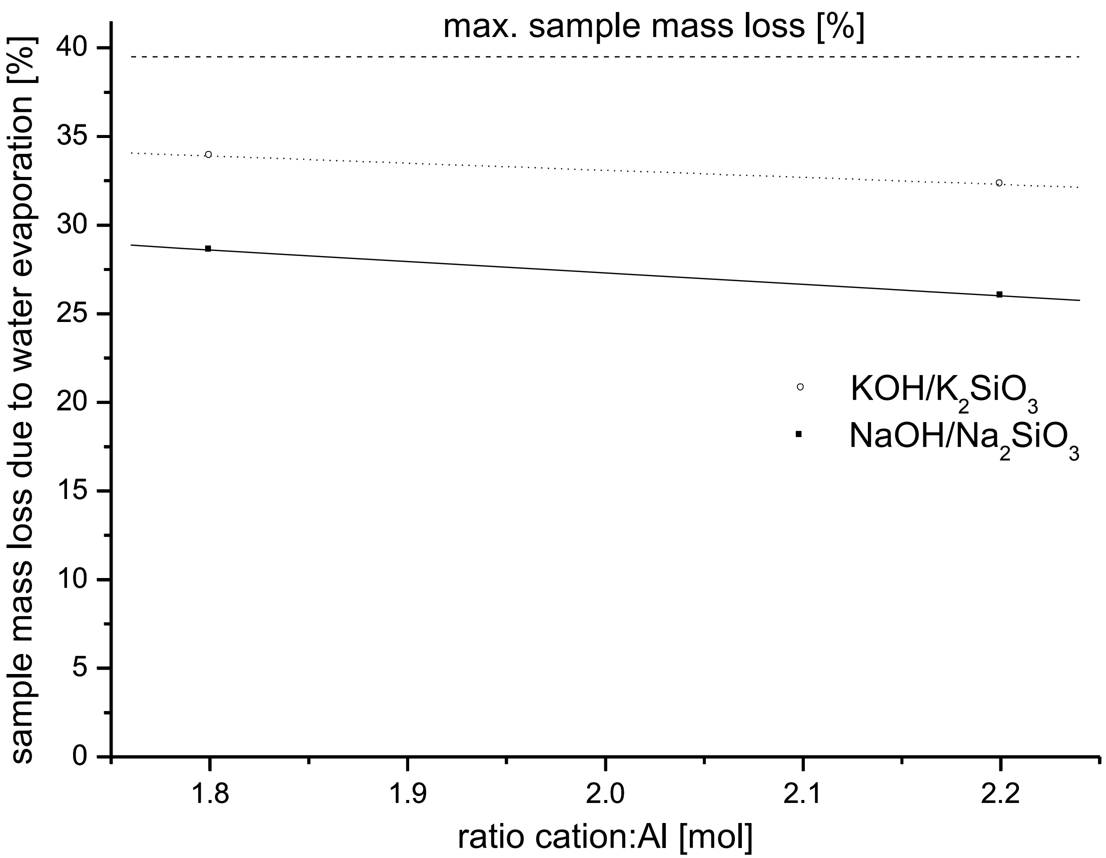
Influence of Na on cracking

Onset point of shrinkage measured using extensometer



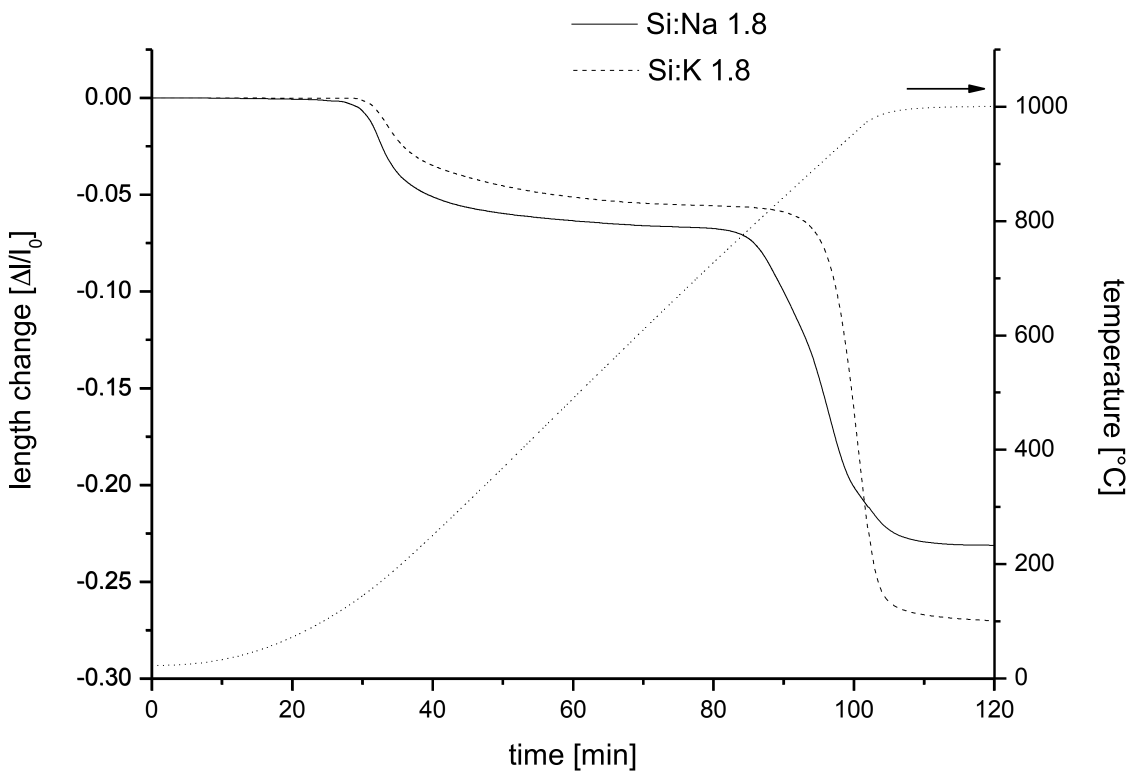
Influence of Na/K and Si ratio on cracking

Onset point of shrinkage measured using extensometer



Influence of Na/K and Si ratio on cracking

Shrinkage during heating determined by dilatometry



Influence of Na/K and Si ratio on cracking

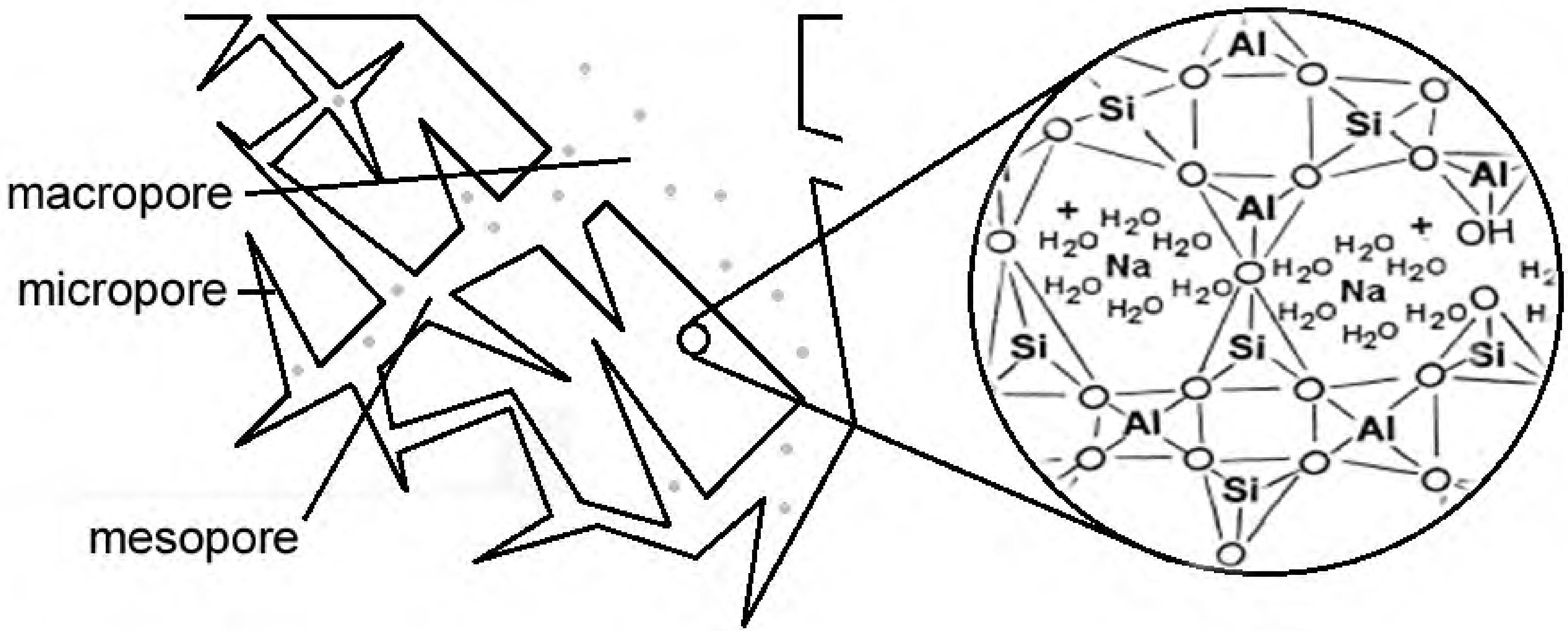
Comparing Na and K

	Na^+	K^+
Radius, Å	0.97	1.33
charge density [Z/r]	1	0.75
$\Delta H°_{hydn}$/kJmol^{-1}	-406	-322

Na has high charge density, means it remains hydrated during geopolymerisation

K has smaller hydration sphere compared to Na and water bond weaker

Conclusion


macropore
micropore
mesopore
Al
Si
Si
Al
Al
+
H_2O
H_2O
H_2O
Na
H_2O
H_2O
H_2O
+
OH
H_2O
H_2O
H_2O
Na
H_2O
H_2O
H_2O
Si
Si
Si
Al
Al
Si

Results to date

Influence of water saturation after cation has lost hydration sphere

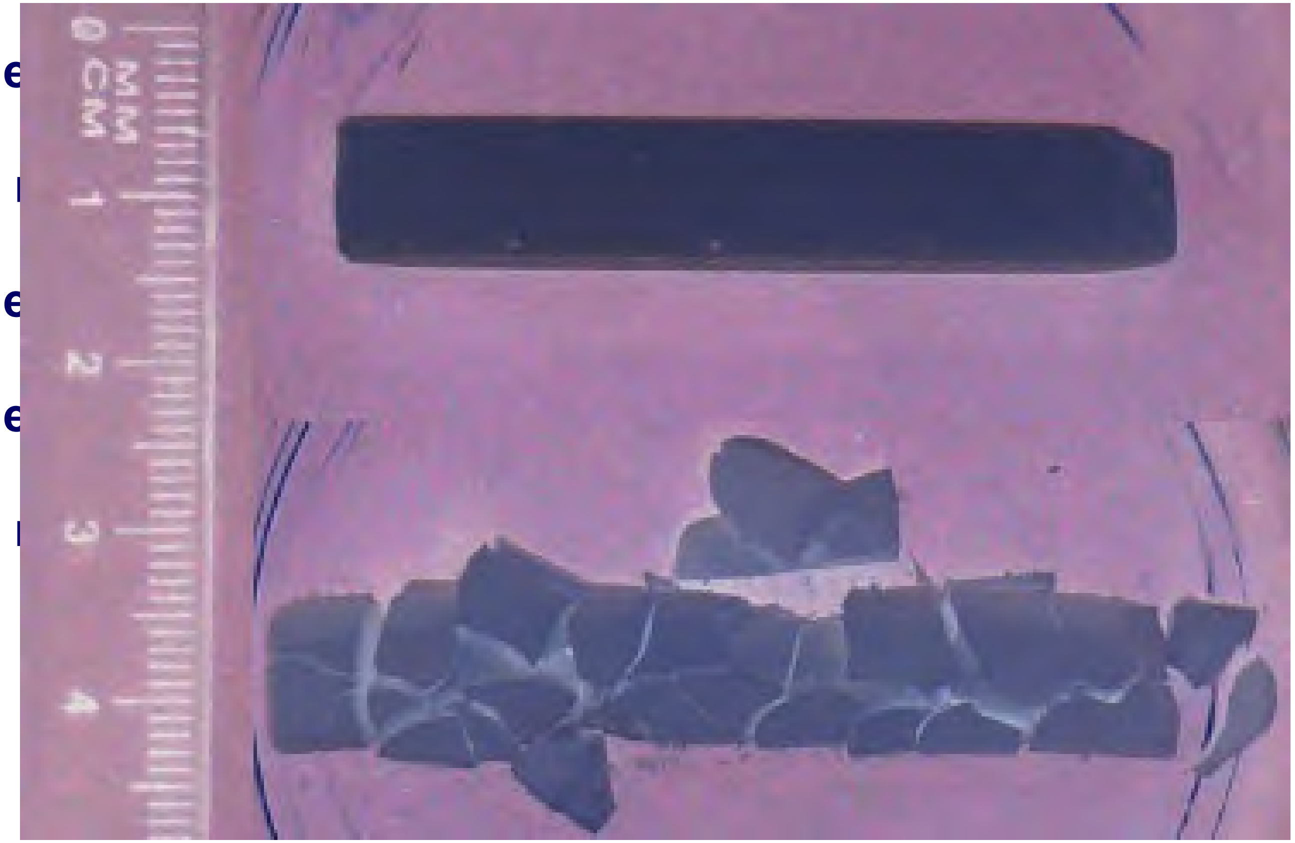
Influe

- I

Influe

Influe

- I



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Thank you for your attention

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