

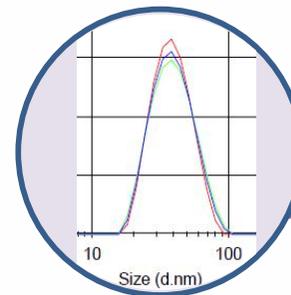
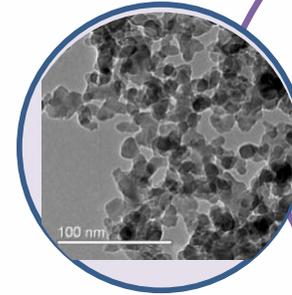


# Production of geopolymer foam with addition of nanoparticles

**Dr. Tomi Nissinen**  
Geopolymer Camp 2018  
10/07/2018



- NAMI – Your Materials Expert
- Nanotechnology
- Foam
- Geopolymer application
- Good to know





# Nano and Advanced Materials Institute Ltd.



- NAMI established in 2006 by Hong Kong government
- Focused on applied research



- Key figures:
  - HK\$ 150M+ annual R&D
  - ~200 technical talents
  - >HK\$ 100M equipment
  - 400+ filed patents
  - 40,000 ft<sup>2</sup> lab area



NAMI  
Your Materials Expert



# Nano and Advanced Materials Institute Ltd.

## MISSION

Cultivate research **Talent**  
Contribute to HK's **Technology** advancement  
Collaborate with industries for **Commercialization**

## R&D MODEL

### Applied Research Eco-system



*NAMI*  
*Your Materials Expert*

**Traditional Research, Development & Implementation Cycle**

納米創意無止境



# Nano and Advanced Materials Institute Ltd.



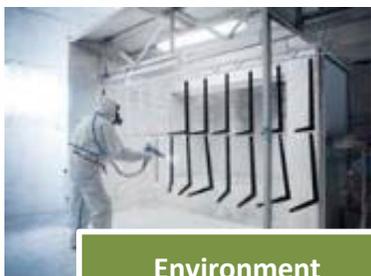
Energy



Healthcare



Electronics



Environment



Construction



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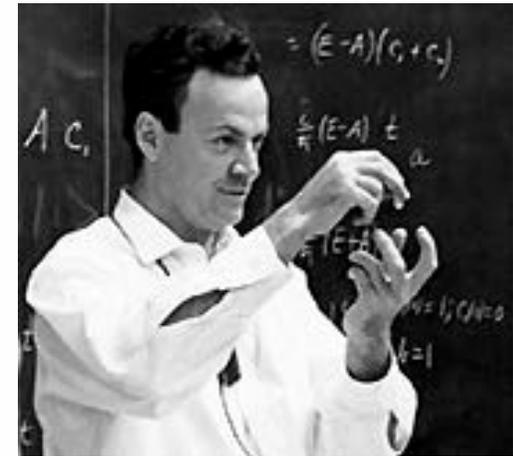
# History of Nanotechnology



Lycurgus cup 4<sup>th</sup> Century  
British Museum, London



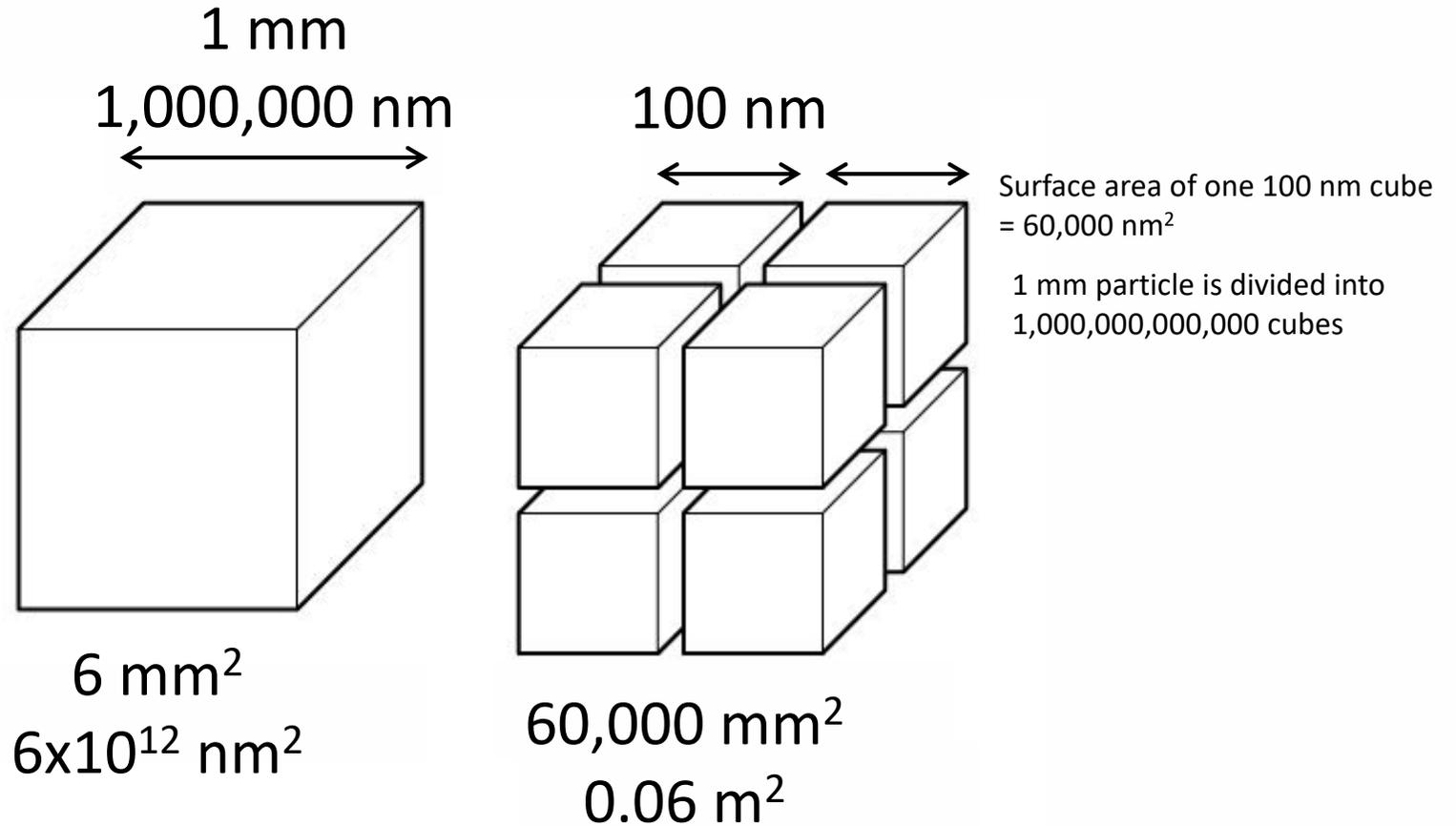
Gold Colloid, Faraday, 1857  
Royal Institute of Science, London



Richard Feynman, "There's Plenty  
of Room at the Bottom" American  
Physical Society meeting at Caltech,  
1959

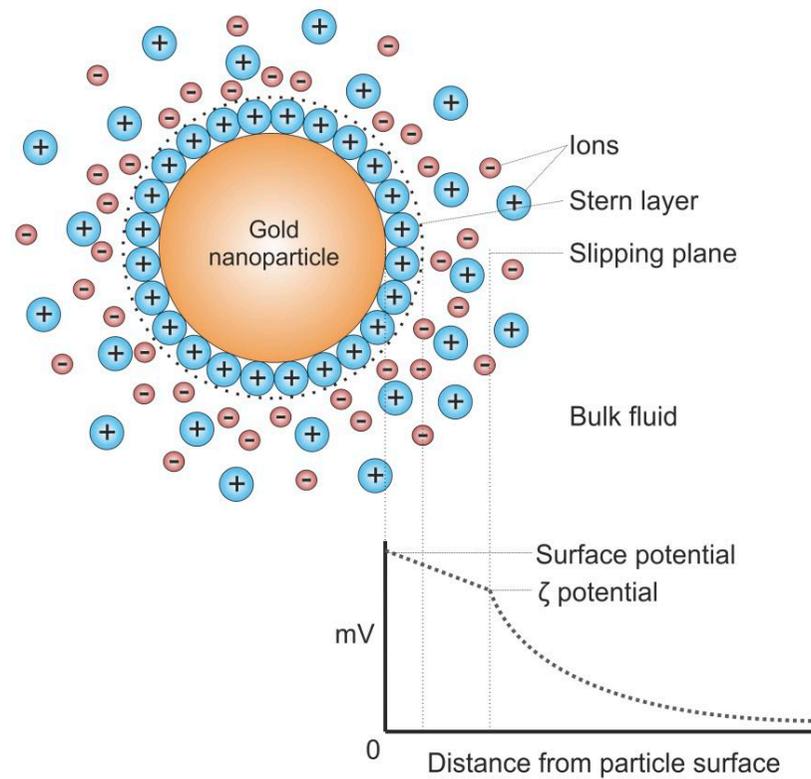


# Key Concepts



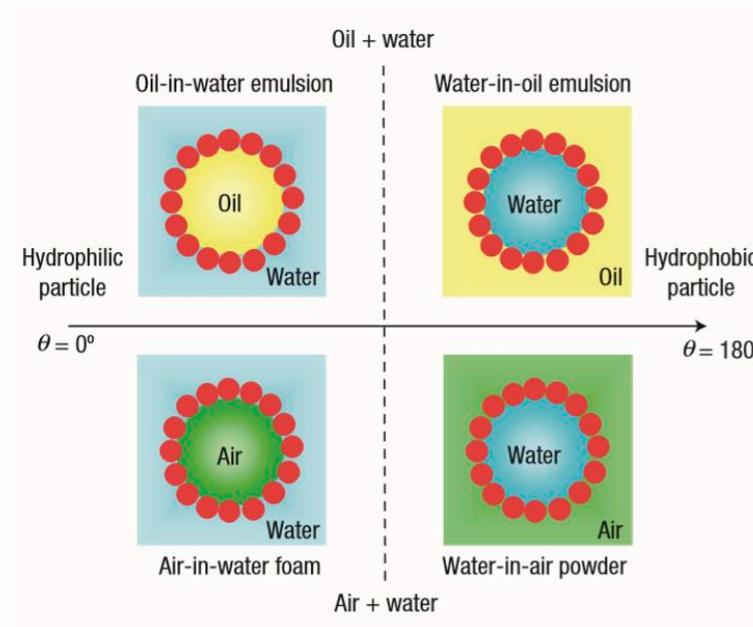


# Key Concepts





# Key Concepts



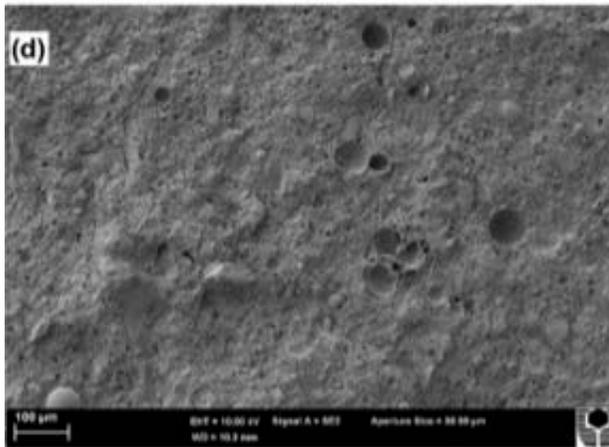


# Nanoparticles in Geopolymer

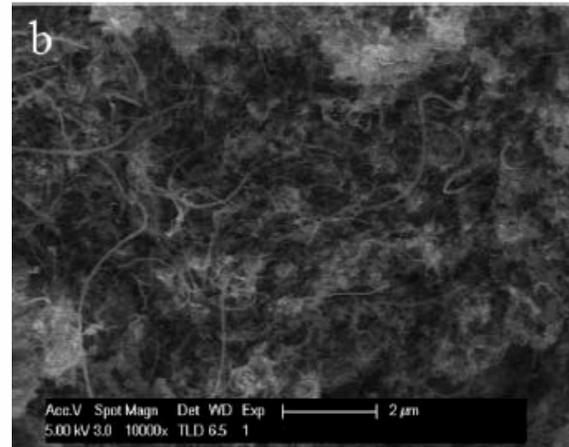
- Strength
- Density
- Water resistance

- Thermal conductivity
- Electrical conductivity
- Load transfer

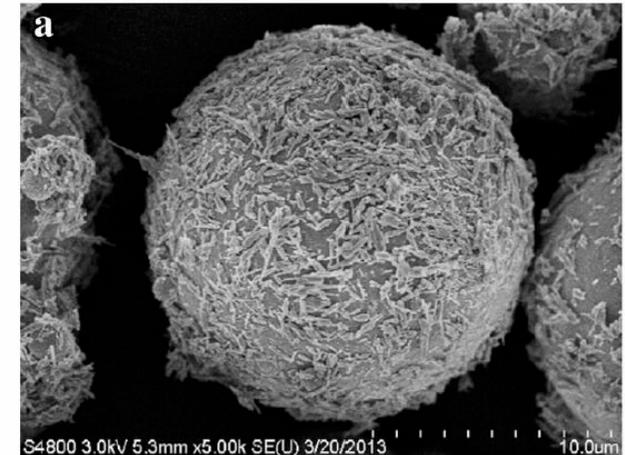
- Retarding effect
- Photocatalytic
- Antibacterial



- ✓ nano-SiO<sub>2</sub>
- ✓ nano-Al<sub>2</sub>O<sub>3</sub>
- ✓ nano-clay



- ✓ Carbon nanotube
- ✓ Graphene oxide



- ✓ Carbon nanotube
- ✓ Graphene oxide
- ✓ TiO<sub>2</sub>
- ✓ nano-Ag



**Go to [menti.com](https://www.menti.com) and use code: 10 48 93**

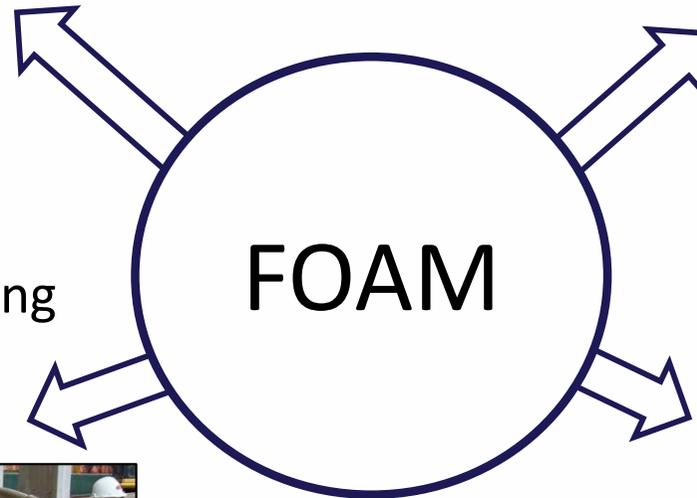


# Motivation

Special applications



Energy-saving construction



Civil Engineering



Environmental protection





# Challenge



Foam



Cement paste



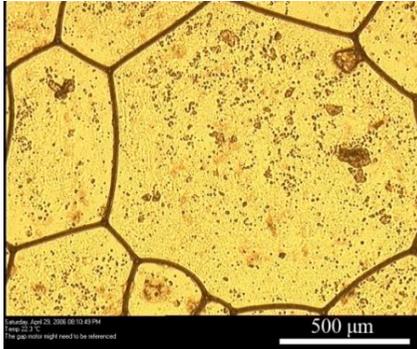
Commercial Foam



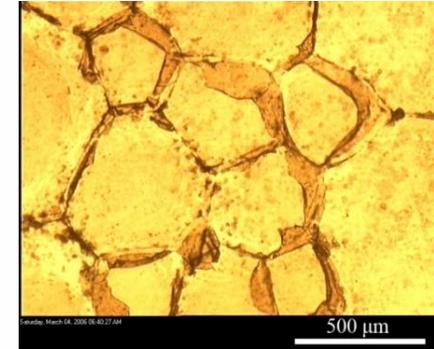
Ultra-stable Foam



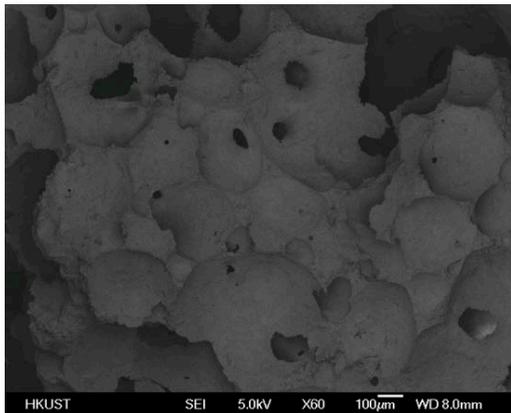
# Solution



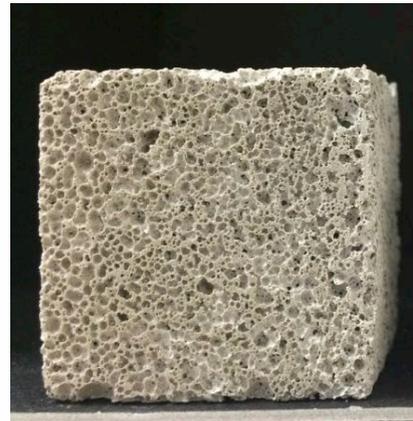
Market available product



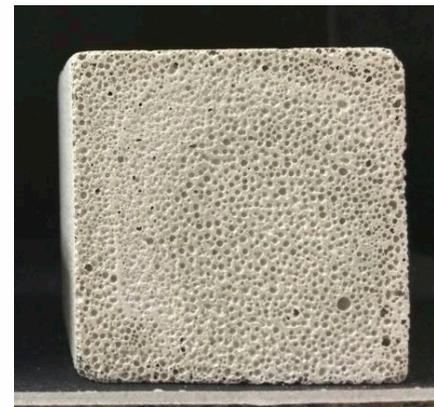
NAMI's NANOFOAM



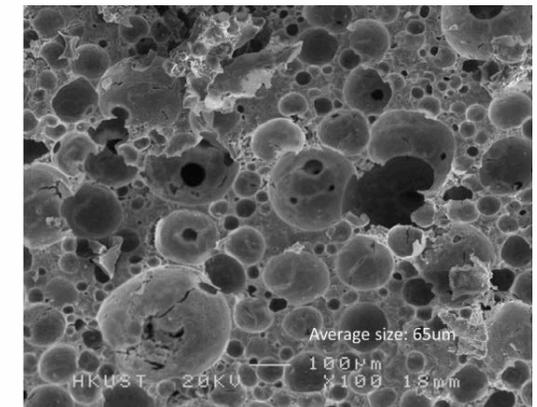
Large pore size, >500 um



450 kg/m<sup>3</sup> 0.4 MPa



450 kg/m<sup>3</sup> 2.5 MPa



Small pore size, 65 um

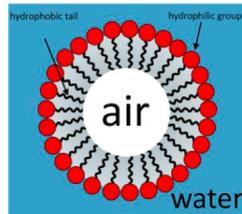
NAMI  
Your Materials Expert



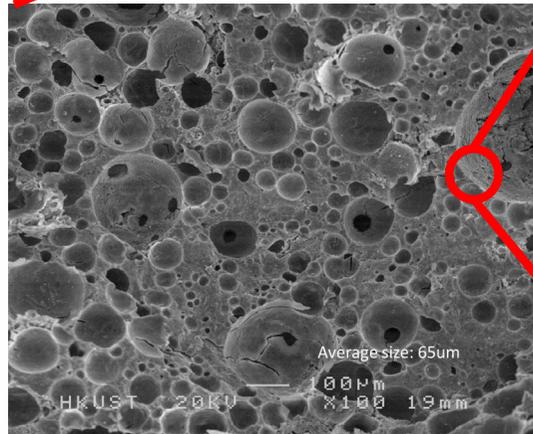
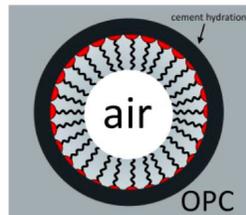
# Solution



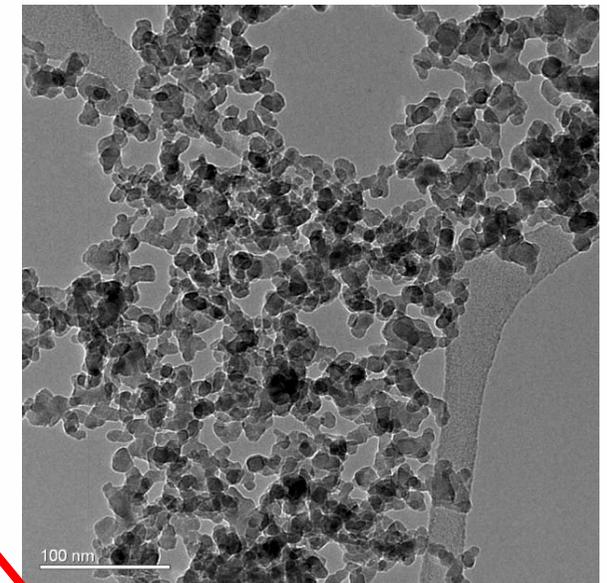
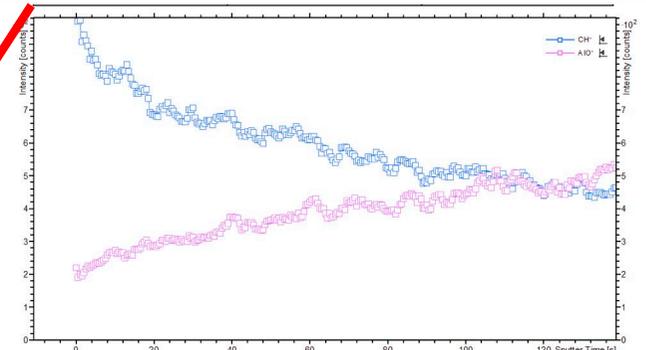
Self-assembly of Nanoparticles



Nanoparticles are part of cement matrix after hydration



SEM, TEM and TOF-SIMS analysis



Modified nanomaterials assemble at the pore surface



# Business case



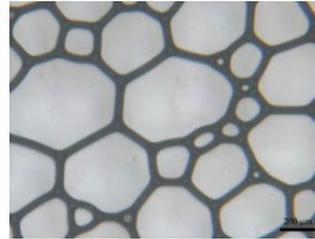
Studio City – Macau approximate indoor  
wall area 140,000 m<sup>2</sup>



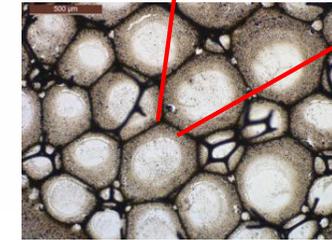
# Foams in Geopolymer



$H_2O_2$   
Al-powder



Traditional foaming  
agent



NAMI's alkaline  
resistant NANOFOAM





# Scaling up tests



Foaming agent mixing



Raw materials mixing



Foam pour into paste



Foam paste mixing



casting



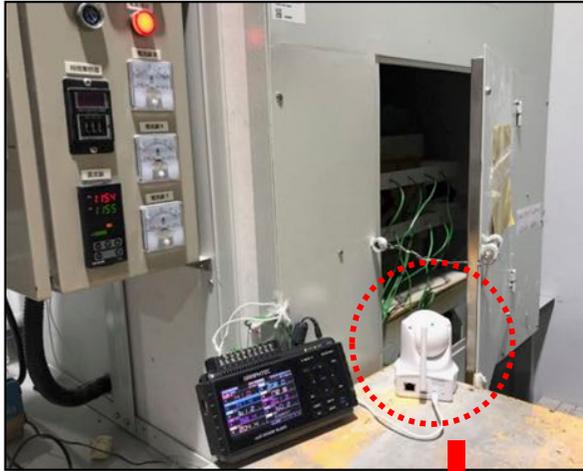
Foam geopolymer wall block

## Product properties:

- ✓ Easy to cast, spread diameter 160-180 mm
- ✓ Smooth surface
- ✓ Density 700 kg/m<sup>3</sup>, 8 MPa CS
- ✓ Density 900 kg/m<sup>3</sup>, 17 MPa CS .



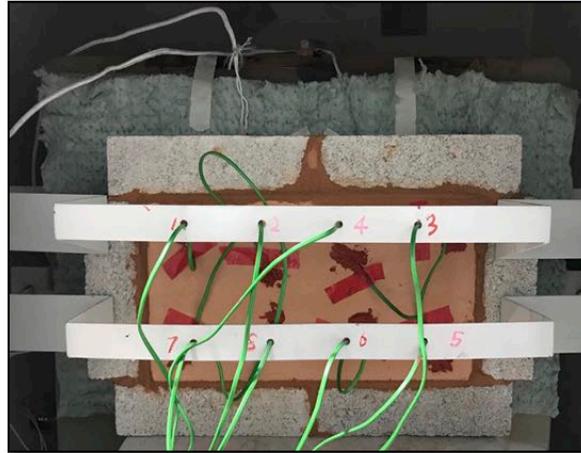
# Testing Procedures: BS EN 1364



Fire resistance test



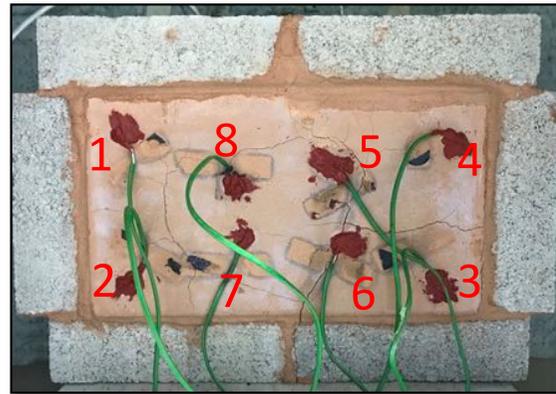
Video monitoring



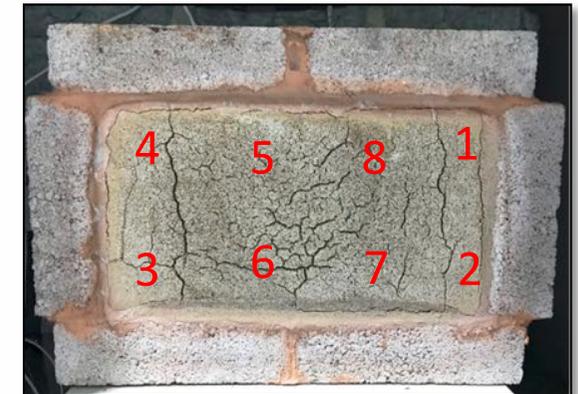
Thermal couples on unexposed surface



Block during test



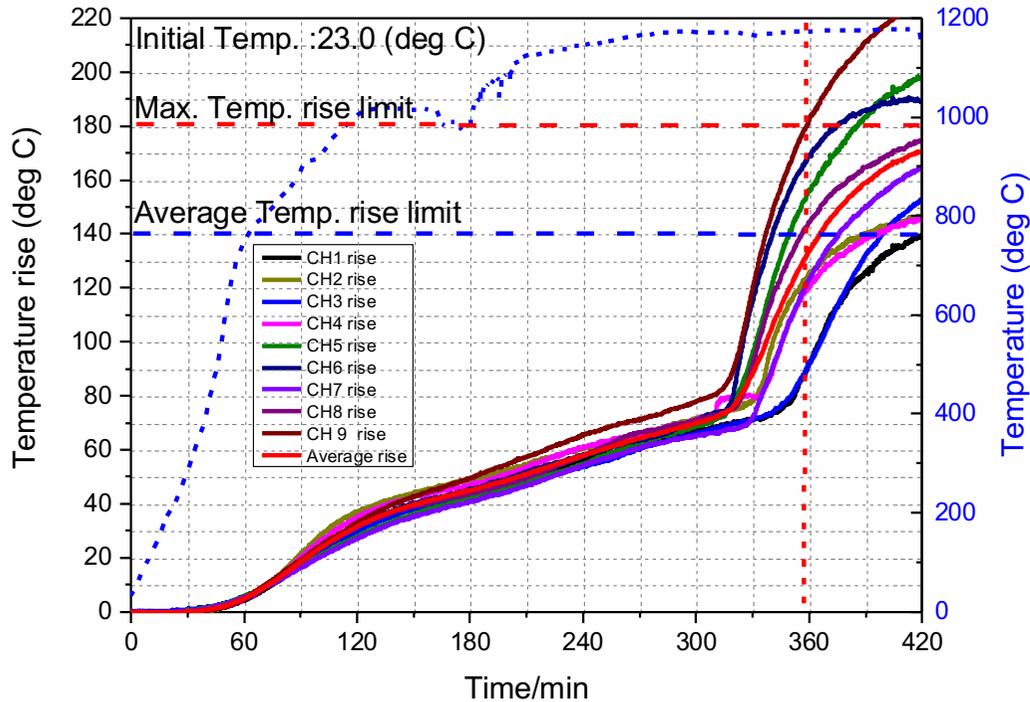
Unexposed surface after test



Exposed surface after test



# Performance



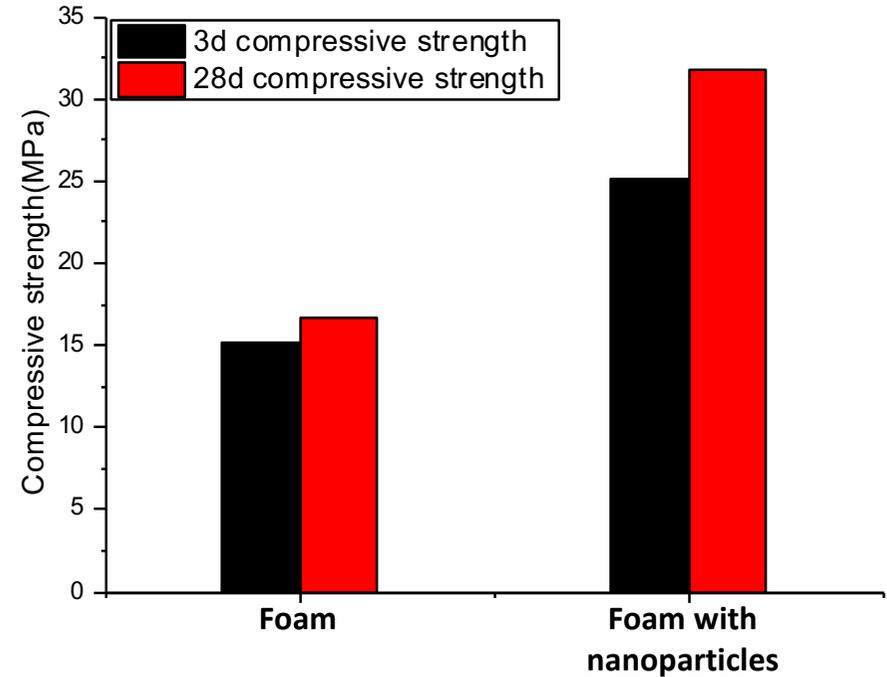
1100 kg/m<sup>3</sup> foam geopolymer wall block fire test according to BS EN 1364. Specimen size 340mm\*190mm\*100mm



Before



After



Effect of nanoparticle foam in 1300 kg/m<sup>3</sup> foam geopolymer



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# Conclusions

- ❖ Foam geopolymer material has been prepared by using nanoparticle stabilized physical foaming agent.
- ❖ Developed material has been applied in manufacturing of indoor partition wall blocks with density of 600-1100 kg/m<sup>3</sup>
- ❖ Scaling up, mechanical and fire performance has been tested in NAMI





# Working with Nanomaterials

❖ Quality of bulk materials

❖ Dispersion methods

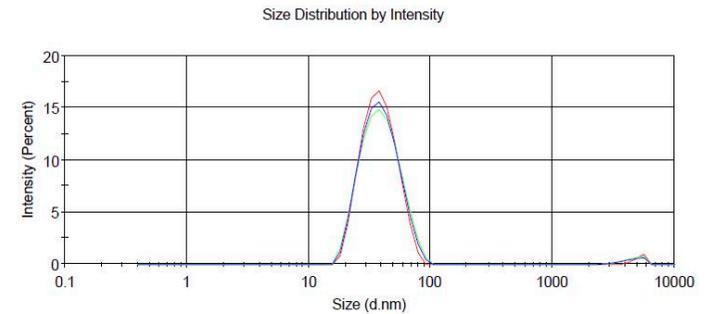
❖ Surface charge, pH and surfactants



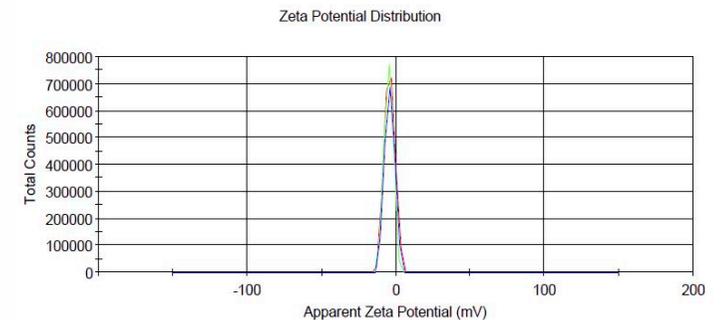
Rotor-type homogenizer



Probe sonicator



Dynamic Light Scattering measurement of size distribution of colloidal silica



Zeta potential measurement of alumina



*Smart Construction Materials Lab (Center of Excellence) @ Science Park*



**NAMI**

***Your Materials Expert***