



# Advanced Materials Developments in Hong Kong

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**Construction & Building Materials**

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# Why Hong Kong?



- **HK - Strategic location for entering into the China market for building materials because...**
  - Abundant feedstocks supplies from China, e.g. fly ash, slag, ...
  - More opportunities for “new” building materials
  - Features of Hong Kong:
    - Renowned worldwide financial centre
    - Intelligent properties (IPs) legal protection

# NAMI - APPLIED R&D CENTRE FUNDED BY HK GOVERNMENT

**Nurturing Hong Kong industry growth through demand driven innovative research models, e.g.**

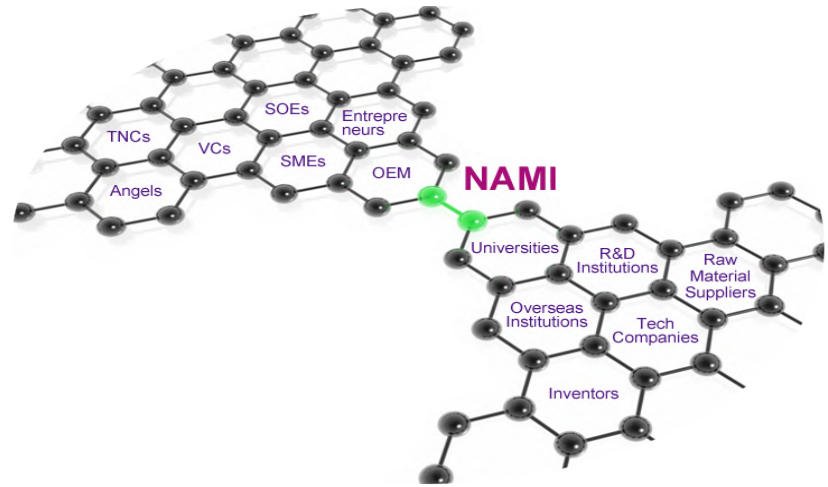
- **Radical innovation**
  - **Performance improvement of existing products**
  - **Product customization – regional feedstocks suppliers and regional market demands**
- ➔ Strategic partnership with local R&D entities**



# About NAMI

## NAMI

- Established in **2006**
- R&D Center **funded by HK Government**
- Focus on **applied** R&D



## Mission

- Developing **core competences in nanotechnology and advanced materials** as part of a powerful technology platform that leads to a wide spectrum of innovative products;
- Acting as the **focal point** for conducting market-driven, demand-led R&D aiming at technology upgrading of regional enterprises;
- Training **human resources** in nanotechnology and advanced materials for the present and future needs of Hong Kong and the Pearl River Delta region.

# M

# Our Office & Laboratories



HKSTP



HKUST

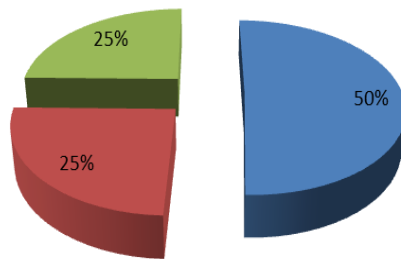




# Our Research Team

## Academic Qualifications

■ PhD ■ Master ■ Bachelor



## Areas of Research

Chemistry/Chemical Engineering/Biochemistry

Material Science/Materials Engineering

Physics

Mechanical/Electrical/Electronic Engineering/Civil Engineering

Biochemistry/Biotechnology/Environmental Engineering

## Universities

**Hong Kong** - HKU, CUHK, HKUST, HKBU, CityU, PolyU

**Overseas** - University of Toronto, University of Washington, University of Michigan, Yale University, Aston University, University of Bristol

**PRC** - Tsinghua University, Beijing University of Aeronautics & Astronautics, South China University of Technology

# M

# Market Sectors




**Construction/  
Building Materials**



**Sustainable Energy**



**Environmental  
Technologies**



**Solid State Lighting &  
Display**

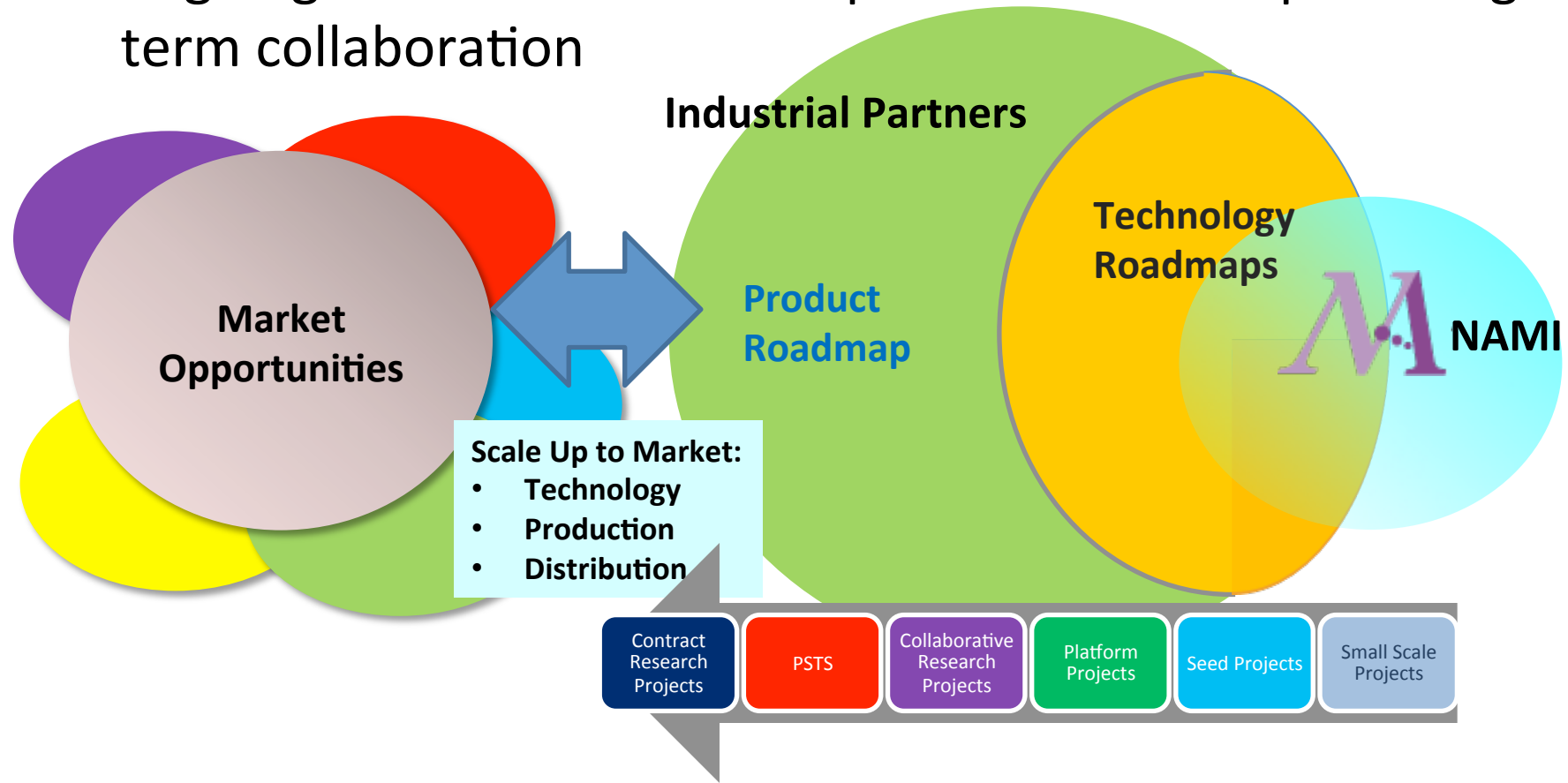


**Bio & Healthcare  
Products**



# DRIVING MARKET DEMAND DRIVEN AND INNOVATIVE COLLABORATIVE RESEARCH

- ❖ Demand driven collaborative research model increases commercial success of applied research
- ❖ Aligning NAMI and industrial partners' roadmap for long term collaboration







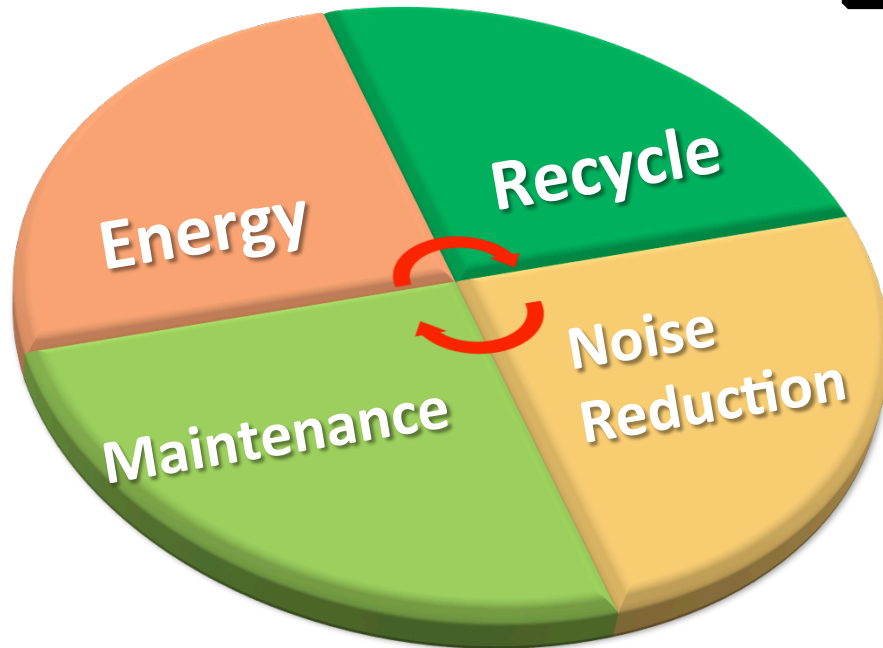
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*Nano and Advanced Materials Institute Limited*

# Intro of Construction & Building Materials Sector at NAMI



# NAMI R&D in Building Materials



**NAMI's focus:**  
Smart & Sustainable Buildings Materials

## □ Why these FOUR focuses:

In Hong Kong...

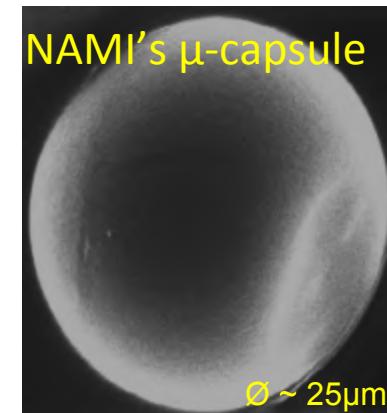
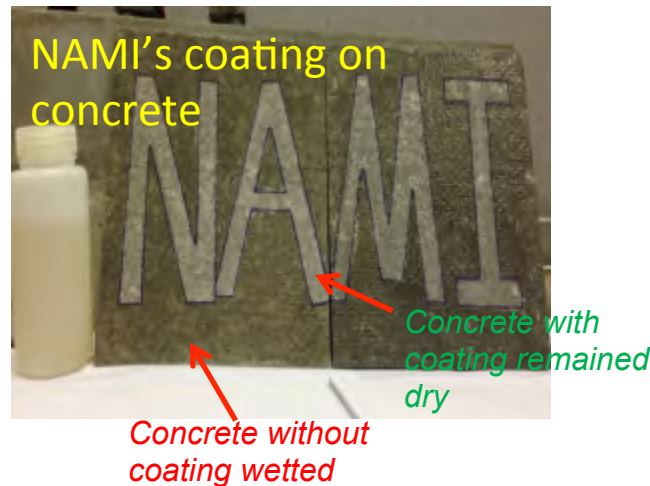
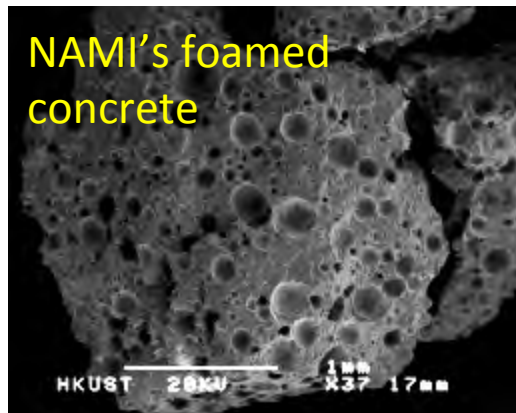
- **Energy:** 1/3 consumed electricity in HK due to air-conditioning
- **Recycle:** 55% waste recycling target by 2020
- **Maintenance:** 40+% buildings over 30 years requiring regular inspection & maintenance
- **Noise:** 600 roads generating 70+dB noise, neighborhood noise

➔ **Nano & advanced materials create innovative material with *new features* to cater the local *market demands***

# Core Technologies of Construction & Building Materials Sector

## □ Core competencies: Advanced materials *formulations & processes* for various applications:

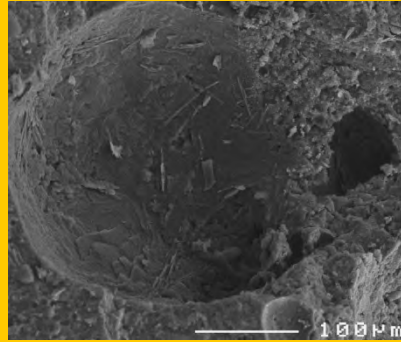
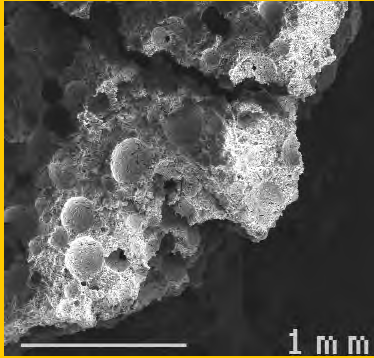
- Examples of cementitious materials: Foamed concrete, water-repelling concrete, rapid-cure concrete, fibre reinforced cementitious materials, VOC-free coating, waterproof rendering, aggregates recycling, etc.
- Examples of polymeric materials: modified polymeric-cementitious waterproof coating, engineering plastics, etc.



# Advanced Cementitious Materials

## Structural-grade foamed concrete

- Compressive strength:  $>30\text{MPa}$
- Thermal conductivity:  $<0.5\text{ W/mK}$



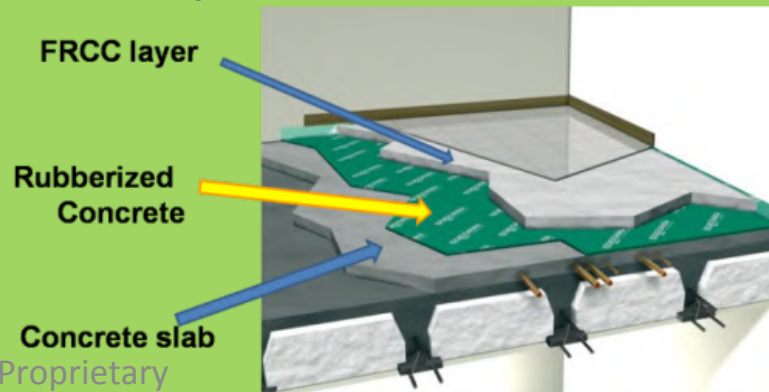
## Cementitious fibre reinforced matrix

- Contain 90% recycled materials
- Water resistance, saltwater resistance and alkali resistance



## Impact sound insulation floor

- Self-compact
- 15+dB impact sound reduction



## Geopolymer for rapid repair

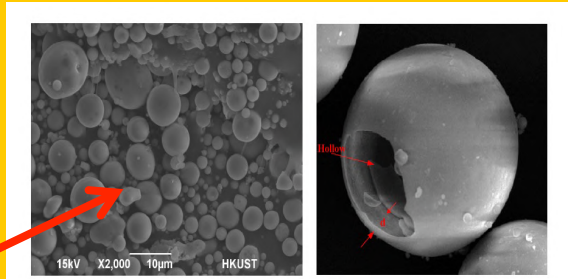
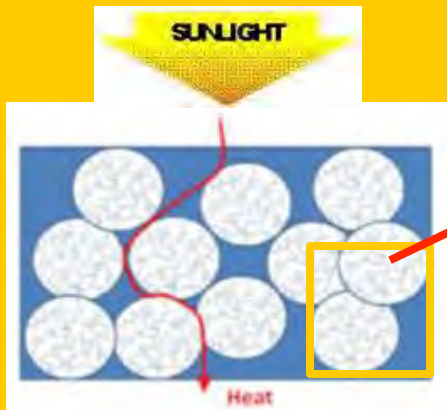
- Rapid cure (2~4 hrs), 1/10 epoxy cost
- Applicable on wet surface



# Advanced Coating for Buildings

## Advanced thermal insulating coating

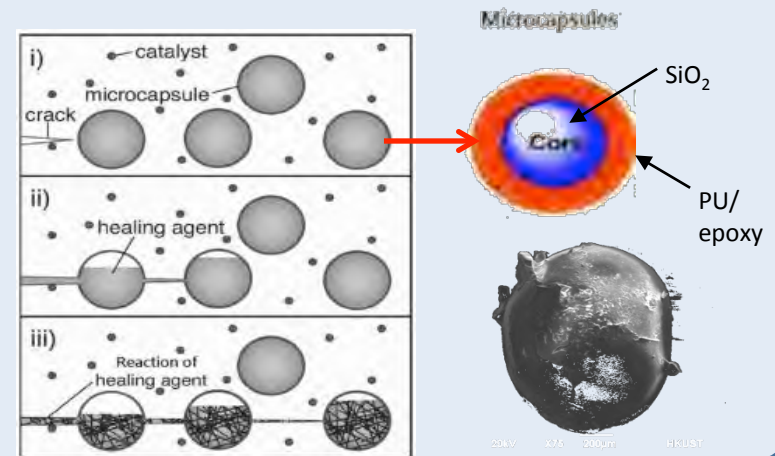
- Cement-based, VOC-free
- Achieved 16°C temperature difference under 0.5mm thick



Air Filled Green Material + Reflective Nanoparticles

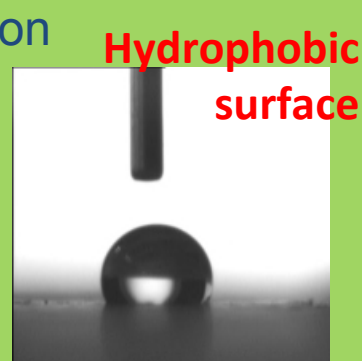
## Self-healing material

- C-S-H (Calcium Silicate Hydrate) based
- “Heal” ~100µm cracks in concrete

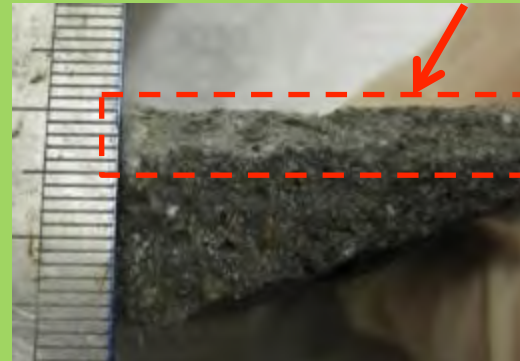


## 2-in-1 anti-carbonation and pore-liner coating

- Hydrophobic, anti-carbonation
- 10 times better Cl & CO<sub>2</sub> resistance than market products



## Coating penetration for enhanced surface protection





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# Rapid Repair Materials for Pavements in Hong Kong

# Market Potentials of Rapid Repair Materials for Highways

- **HK road network: 2,075km in total length, in which**
  - **Approx 75% are bitumen pavements, 25% are concrete pavement**
- **Typical design life:**
  - **Bitumen pavement: 20 years**
  - **Concrete pavement: 40 years**



# Advantage of Bitumen Pavement

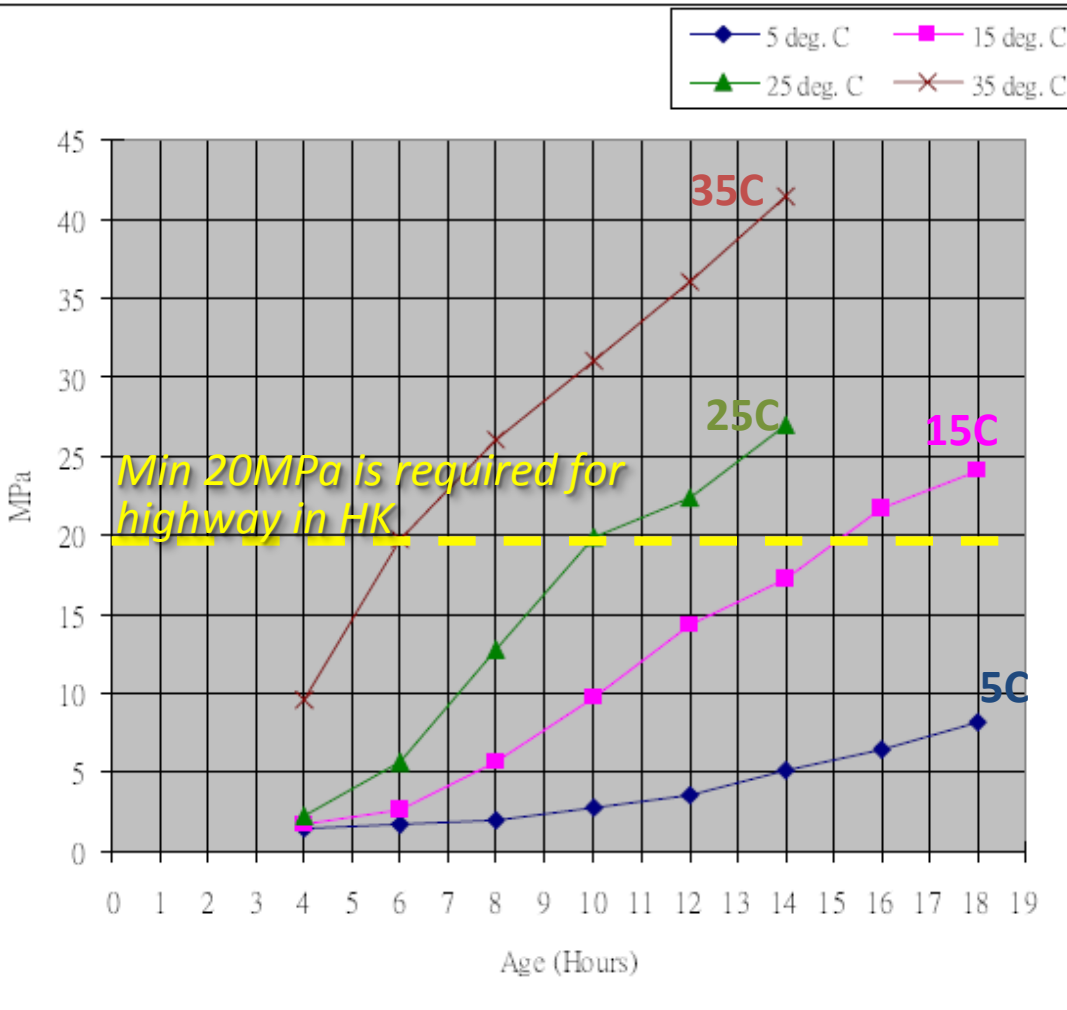
- Why bitumen (flexible) pavement is more common in HK?
  - Less traffic impact caused by repair and maintenance.
  - However...
    - “...this approach (flexible pavement) is **not necessarily cost effective**, in particular when the **oil price** is on a far steeper rising trend in comparison with cement... maintenance **difficulty of rigid pavement (concrete) may not be an insurmountable** factor either, taking into account the state-of-the-art **technology**”

*Guidance notes on pavement design for carriageway construction, Highway Department, HKSAR, Sept 2013*





# Common Rapid Repair Cementitious Concrete



- Superplasticizer with set accelerator
  - >6 local suppliers
  - Approx **12h** for traffic open
  - **4~5 times** costs of Portland cement
- Calcium sulfoaluminate cement (CSA)
  - >3 local suppliers
  - Approx **2h** for traffic open
  - **6~12 times** costs of Portland cement
  - Yet, due to its difficulties of **quality control of on-site mixing**, high cost, it is not recommended in HK

Compressive strength development of rapid hardening

concrete under different temperature

Source: Highway Department, HKSAR, Mar 2012

# Comparisons of Various Repair Materials for Highway

Material				Typical Material Properties						
	Thickness Limitations	Installation Temperature	Curing	Drying Shrinkage	Coefficient of Thermal Expansion	Compressive Strength (MPa)				Elastic Modulus (GPa)
						2 Hrs	24 Hr	3 Days	28 days	
Portland Cement Concrete	> 40mm	5 – 32°C	Wet 7 days	Moderate	$7-12 \times 10^{-6}$	0	5	20	40	23
Rapid Hardening Cementitious Concrete	> 50mm	5 – 30°C	Wet 2-12hrs	Moderate	$8-20 \times 10^{-6}$	0-20	20-40	-	55-85	1-30
Polymer Concrete	>30mm	7 – 35°C	Wet 2-3hrs	Low	$7-12 \times 10^{-6}$	20	30	40	50	22
Epoxy Resin Mortar	>5mm	10 – 32°C	Air	Low	$25-30 \times 10^{-6}$	0	70	80	85	0.5-20
Polyester Resin Mortar	>5mm	0 - 60°C	Air	Low-Moderate	$25-35 \times 10^{-6}$	60	80	-	100	2-10

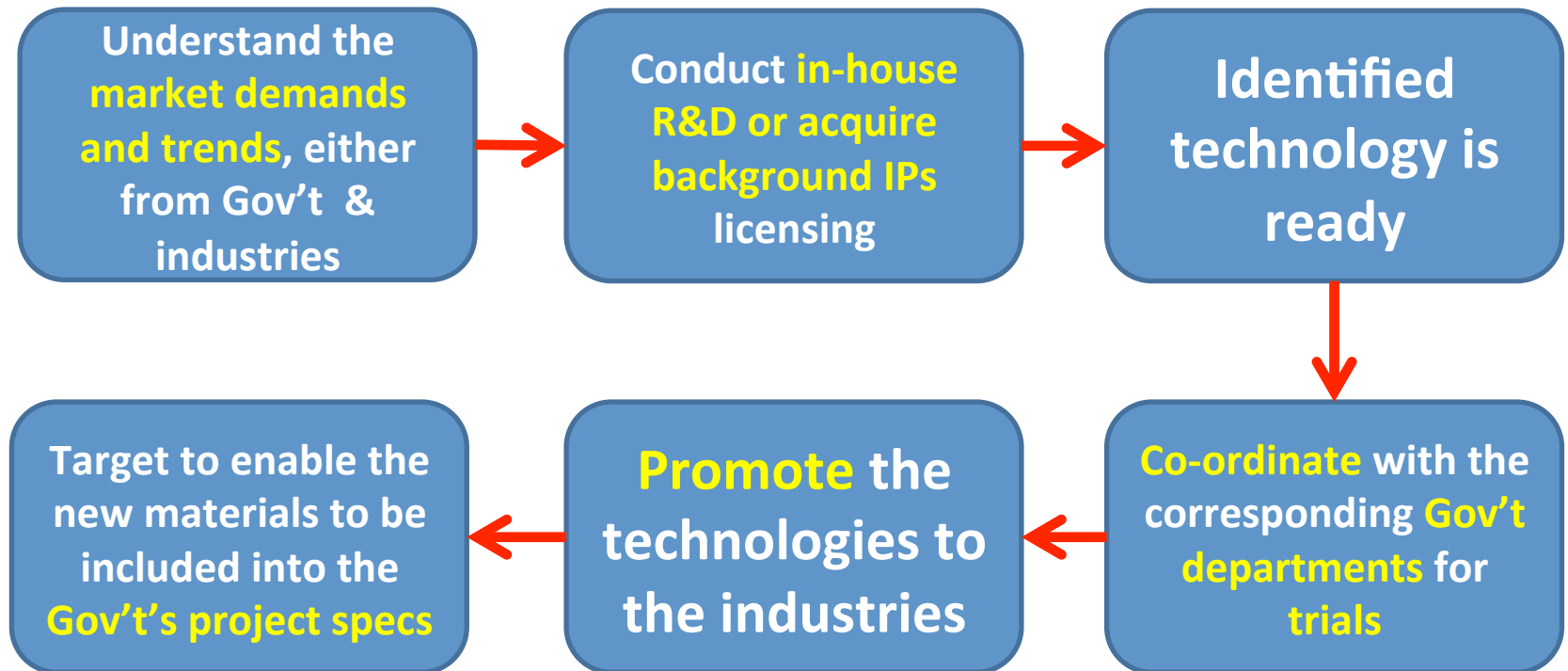
Source: Highway Department, HKSAR, Mar 2012

- Early strength (>20MPa, 2h) is achievable by both cementitious and polymeric materials.
- Coef. thermal expansion mismatch of polymeric mortar can be compensated by applying fabric inside, but the increased cost and quality control are of concern.

# Lessons Learnt from Highway Department of Hong Kong

- Due to the increasing **oil price** and **cementitious materials technologies advancement**, the Gov't department has sufficient incentives to switch back to rigid (concrete) pavement.
- **Rapid cure cementitious materials** are strongly welcome by the department, as far as the minimum requirements can be achieved, i.e. 20MPa, 4h, and cost-effective.
- Yet, the “new” materials to be adopted by the department have to be **commonly available** in the market for the Gov't to include them into the procurement specs, e.g. **more than one supplier**.

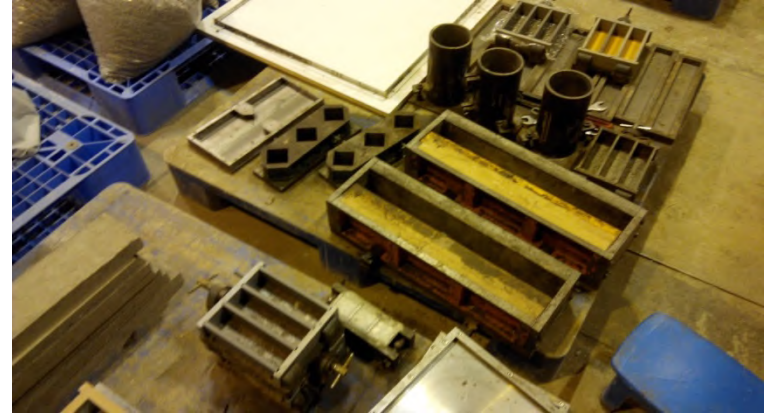
# Strategy of Introducing New Materials for Construction & Building Industries



# What NAMI is Doing on Geopolymer?

- NAMI has just received approval from HK Gov't working on geopolymer, target for **rapid repair** for **concrete pavement** and **underground sewage ducts repair**.
- This **16 months** project is targeted to be started from Sep 2014.
- **Collaborations** with universities/institutes and industries are welcome.
- **Graduates** with related background are **strongly** welcome to join us.

# Facilities Available at HKUST-NAMI





**Thank You!**

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