

Eco-driven Repair Mortar Technology Recycled Glass and Slag Based Approach

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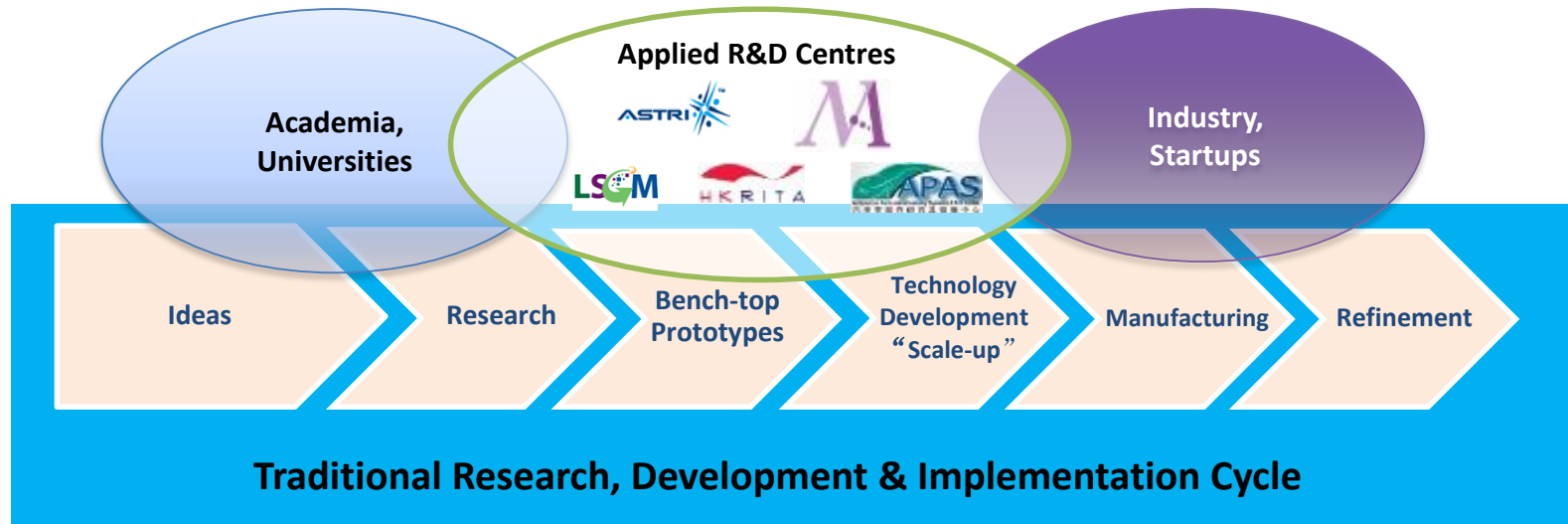
9 May 2018



NAMI: An Applied Research Centre

NAMI established in 2006 by Hong Kong Government to be an integral part of the Applied Research Eco-system to offer technology upgrade to HK industries

Applied Research Eco-system





NAMI

MISSION

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

Business Model

- Demand-driven Research
- Materials-focused
- Industrial Collaboration
- University / Research Institute Cooperation



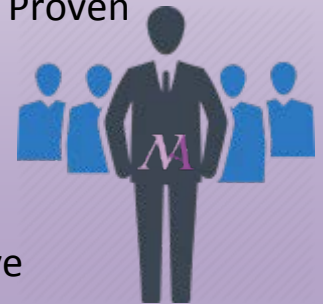
Value Proposition

- Trained Researchers
- Extensive Equipment
- Innovation Technology Fund
- Dollar Efficient Research



Technology Clusters

- World Class
- Forefront, leading-edge R&D
- Applied & Proven
- Knowhow Cumulative





nami at a Glance



- ❖ Focused on:
 - Applied R&D on Materials
 - Commercialisation
- ❖ Support HK industries
- ❖ 11 years of history



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Annual R&D Investment
HK\$150M+



Equipment
>\$100M



Technical Talents
~200 (>50% PhD)



Lab area
40,000 ft²



Filed patents
400+



Market Sector & Core Competence



Energy



Healthcare



Electronics

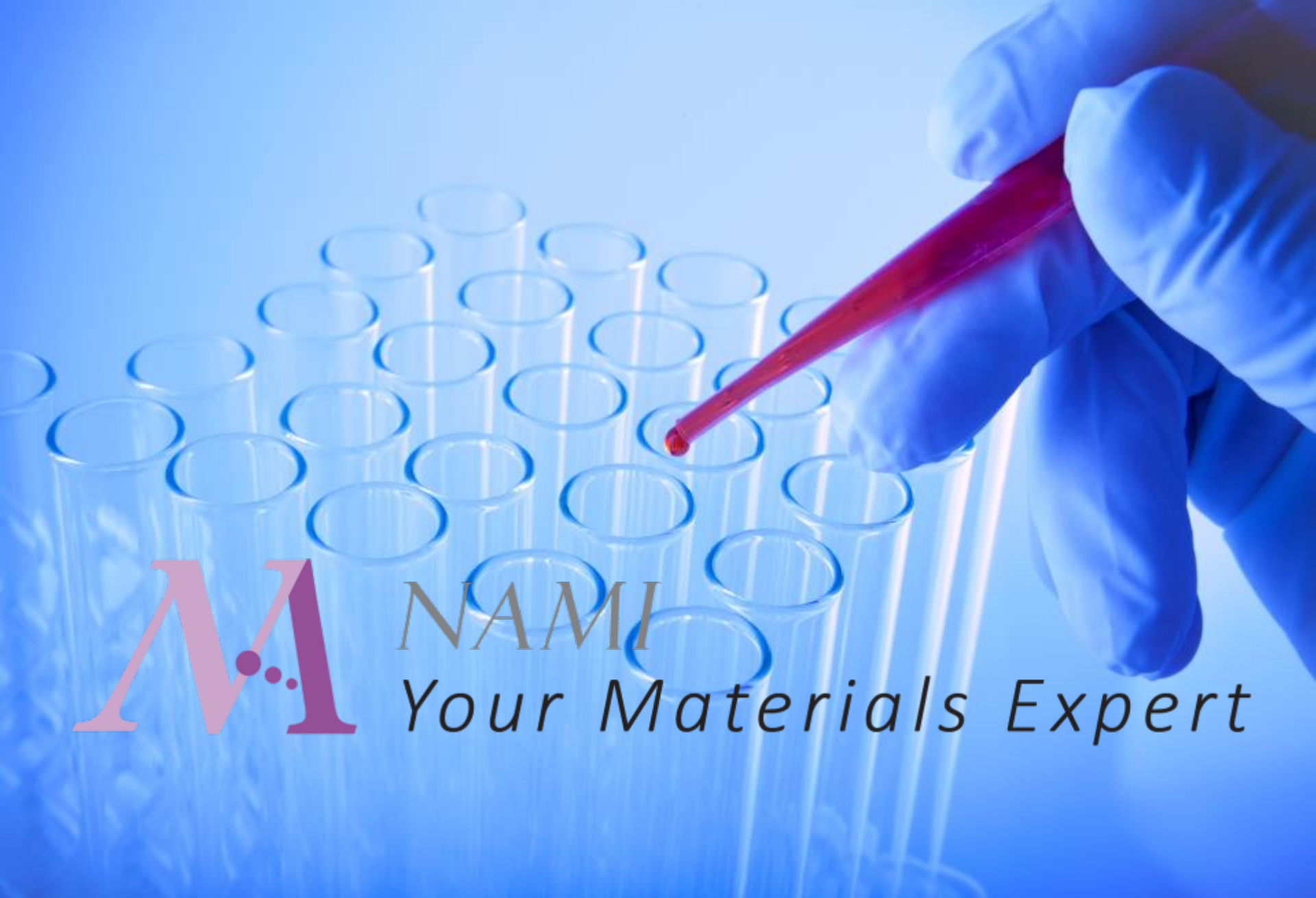


Environment



Construction





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Background (1/3)

❖ Glass

- mainly composed of **silica (SiO_2)** added with a small amount of **soda ash (Na_2CO_3)** or **potash (K_2CO_3)**, **lime (CaO)** and a few other additives
 - **Chemically inert and stable**
 - **Hardly decompose** (Biodegrading glass bottles in a landfill takes **1 million years**)
- ❖ Hong Kong generates more than **500,000 waste glass bottles** every day, around 250 tonnes per day
- Occupy landfills permanently
 - Deplete valuable landfill space





Background (2/3)

- ❖ High chemical stability → suitable for reusing and recycling
- ❖ HKSAR Government continuously strive for increasing the recycling rate of glass to 60% or above
 - ✓ Reduce waste disposal
 - ✓ Relieve pressure on our landfills
- ❖ Recycled glass applications
 - ✓ Paving blocks
 - ✓ Decorative wall panels
 - ✓ Concrete repair mortar (presented in the following slides)

多管齊下提高玻璃樽回收率

2016年05月28日



要聞

2016年5月28日 星期六

玻璃樽徵費1公升瓶約1元 資助回收再造 盼回收率增至六成

玻璃樽徵費1公升瓶約1元 資助回收再
造 盼回收率增至六成





Background (3/3)

Parent ITF Project Information (ITP/018/14NP)

Features & Highlights:

- ✓ Green repair mortar with **70% waste/recycled materials** VS. conventional repair mortar without waste/recycled material inside
- ✓ **Comparable mechanical property** to conventional repair mortar
- ✓ Low shrinkage **≤ 300 micron strains** (half of conventional repair mortar)
- ✓ Cost effective: **30% lower** than conventional repair mortar
- ✓ Fire resistance: **≥ 60 min** for integrity

Raw materials



Recycled Glass

Ground Granulated
Blast-furnace Slag

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Full-scale fire test



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Public Sector Trial Scheme (PSTS)

- Application of **sustainable building materials** and **waste recycling** is one of green initiatives of HKSAR Government.
- NAMI's technology, incorporated with waste/recycled materials available locally, is a **green alternative** to address the needs of sustainable building materials for concrete repair work
- Public Sector Trial Scheme (PSTS) for the green repair mortar is started with the collaboration of ArchSD

Current repair method don't incorporate the use of waste/recycled materials

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Provide green repair mortar with satisfactory mechanical properties



PSTS Benefits

- Through the PSTS, it can help to build up a substantial **job reference** which facilitates commercialization of this **cost effective** and **green** building material
- To validate the **scale-up capability**, engineering feasibility and repairing efficiency of the developed material through **on-site application**
- Upon successful application of NAMI's technology, it is anticipated to gradually replace part of traditional cement-sand mortar and become a **material reference** for concrete repair.





Locations for Concrete Repair

- Various locations with **the following conditions** were repaired to demonstrate the applicability of green repair mortar
 - ❖ Size of repair area (e.g. 500mm×500mm)
 - ❖ Depth of repair area
 - ❖ Grade of substrate concrete (e.g. C25 or C30)
 - ❖ Outdoor or indoor
 - ❖ Moisture condition

The tests on the repair material were carried out*

- a) 28 day-compressive strength ≥ 30 MPa.
- b) Tensile bonding between concrete slab and repair mortar **fail in parent substrate.**



Typical Repair Location



Locations for Concrete Repair

- ❖ The repaired works at the designated sites were implemented by appointed contractors
- ❖ Approximately 20m² of defective areas in existing buildings were repaired using the green repair mortar.
- ❖ Five sites were selected, as tabulated below:

No. of Trial Application	Location	Area Repaired
1a	Health Centre	0.42m ²
2a	Public Market	4.02m ²
2b	Public Market	0.5m ²
1b	Health Centre	3.82m ²
2c	Public Market	4.44m ²
3	Government Quarters	0.9m ²
4	Public Toilet	4.31m ²
5	Public Market	1.82m ²



NAMI's Eco-mortar in Action



★ NAMI's Eco-mortar
in action



Trial application procedure (1/2)

- **Preparation of mortar:** mortar material and shrinkage reducing agent (SRA) aqueous solution were allowed to be mixed with a handheld mixer for 7 min.



Pre-mixed
mortar
materials



SRA



Water



Mix for 7 min.



Ready for application.



Trial application procedure (2/2)

- **Application of bond coat and mortar**



To hack off defective concrete and remove steel bar rust.

To apply a layer of bond coat.

To apply a layer of repair mortar (1st layer).

To touch up the final layer.



Site Locations (1/6)

Health Centre



Below windows of staircase



Ceiling at toilet



Wall at the outdoor roof



Site Locations (2/6)

Public Market



Ceiling at 2/F



Beam on 2/F



Parapet along the corridor



Site Locations (3/6)

Government Quarters



Three locations at 5/F of ceiling beams



Site Locations (4/6)

Public Toilet



Ceiling at Female Toilet



Site Locations (5/6)

Public Toilet



Ceiling at Female Toilet



Site Locations (6/6)

Public Market



Ceiling



Compressive Strength Results

Trial	Location	7 day Comp Strength (MPa)	28 day Comp Strength (MPa)
1a	Health Centre	20	33
2a	Public Market	22	34
2b	Public Market	28	36
1b	Health Centre	25	31
2c	Public Market	25	31
3	Government Quarters	24	40
4	Public Toilet	29	35
5	Public Market	32	40



Pull-off Test Results (1/4)

- ❖ Adhesion strength of patch repairs was determined by the pull-off test
- ❖ Criteria:
 - Fracture shall be at least half in the substrate concrete
 - The pull-off stress is not less than 1/4 (i.e. 0.5MPa) of the minimum 7 days bond strength of the repair mortar.



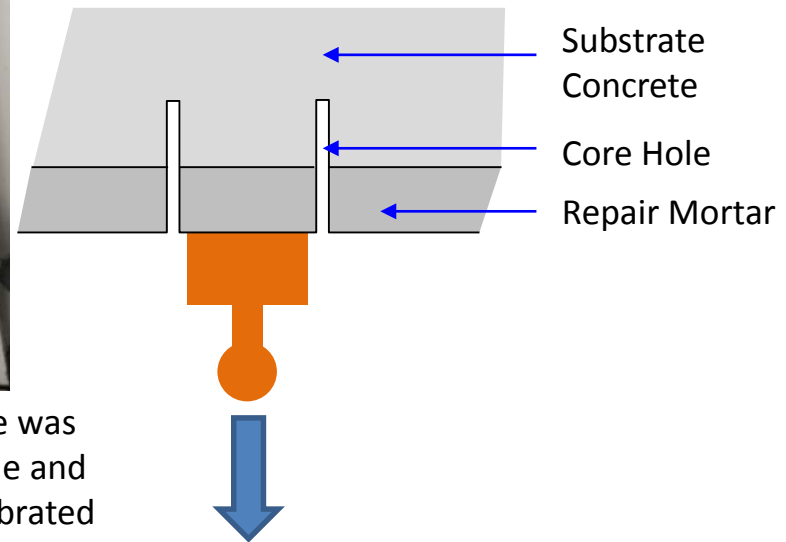
Identify re-bar position



75mm dia. core containing full thickness of the repair



A suitable metal plate was glued to the cored hole and was pulled using a calibrated device until failure occurs.





Pull-off Test Results (1/4)

Pull-off Test



Site

Results and Comments

Location 1

Location 2

Location 3

Health Centre

PASS

There are 50% failure in both mortar and concrete substrate.

Pull-off strength is 0.75MPa.

The failure mode is 100% in the concrete substrate.

Location 1

Location 2

Location 3

Public Market

PASS

The failure mode is 100% in the concrete substrate.

The failure mode is 100% in the concrete substrate.

Pull-off strength is 0.6MPa.

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Pull-off Test Results (2/4)

Site	Results and Comments			
	Location 1			
Public Market PASS	There is 50% failure in both mortar and concrete substrate.			
	Location 1	Location 2	Location 3	Location 4
Health Centre PASS	There are 40% failure in mortar and 60% failure in concrete substrate.	There are 50% failure in both mortar and concrete substrate.	There are 40% failure in the interface between the mortar layer and the concrete substrate and 60% failure in the concrete substrate.	There are 40% failure in mortar and 60% failure in concrete substrate.





Pull-off Test Results (3/4)

Site	Results and Comments			
	Location 1	Location 2		
Public Market 	The failure mode is 100% at the interface between the mortar layer and the concrete substrate.	Pull-off strength is 0.6MPa.		
	Location 1	Location 2	Location 3	Location 4
Government Quarters 	There are 20% failure in mortar and 80% failure in concrete substrate.	There are 50% failure in both mortar and concrete substrate.	Pull-off strength is 1.1 MPa.	There are 60% failure in mortar and 40% failure in concrete substrate.



Pull-off Test Results (4/4)

Site	Results and Comments	
	Location 1	Location 2
Public Toilet 	The failure mode is 100% in the concrete substrate.	The failure mode is 100% in the concrete substrate.
	Location 1	
Public Market 	There are 5% failure in mortar and 95% failure in concrete substrate.	



Conclusion

- NAMI's environmental mortar was developed with the use of at least 70% waste/recycled materials.
- The environmental mortar was used to repair a total of 20.23 m² of defective area in 5 existing buildings, including outdoor and indoor areas at ceilings, beams, parapet, etc.
- The environmental mortar material can pass the required tests: compressive strength of repair mortar cubes ≥ 30 MPa; failure in the parent substrate in the pull-off tests.
- With the outstanding performance, competitive cost and sustainability, NAMI's environmental mortar has enormous potential to be commercialized in near future.

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