Potential Applications of Geopolymer Technologies in Hong Kong

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Why Hong Kong?

- Strategically located at the heart of Asia, and alongside most exciting material markets
- Abundant feedstock supplies from China, such as metakaolin, fly ash, slag, etc.
- Opportunities for “new” building materials
- Renowned worldwide financial center
- Legal protection of intelligent properties (IPs)
NAMI – an Applied Research Centre

- NAMI is established in 2006 by HK Government
- Filling the gap between research & applications
- Offer technology upgrade of HK industries
Concrete Usage in HK

• Annual consumption per person is ~5 times of the world average
Carbon Footprint of Cement

• The cement industry creating more than 5% of worldwide greenhouse gas CO₂ emission

• One third of this was produced in Asia

• Urgent & local need for eco-friendly alternatives
Geopolymer Technology

• Utilizing metakaolin, slag, fly ash, clay, etc., geopolymer cement (GpC) is a green alternative

• Unique features including
  ➢ Rapid early strength
  ➢ Acid resistant
  ➢ VOC free

• Geopolymer based materials (GpM) can be tailored for different application scenarios

• Contributes to the sustainable development & supported by government funding
Recycling by Geopolymerization

- Ground granulated blast-furnace slag (GGBS) is a by-product of iron and steel-making.
- Annual production in China only is about 15~20 million tons.
- With geopolymer technology, GGBS can be recycled & polymerized to develop binding strength.
- A win-win solution to the environmental issues.
Rapid Repair of Highways

• Demand for cost effective rapid repair materials for urgent & emergency cases

• Advantage over organic repair materials
  ➢ Applicable on wet surface
  ➢ Utilizing recycle materials
  ➢ Much lower cost
  ➢ VOC free
Maintenance of Sewerage System

• Concrete sewers under attack by sulfuric acid
• Rehabilitation and improvement program
• A huge demand for sewer maintenance
  ➢ Patch repair, sacrificing layer, repair lining, etc.
• Excellent chemical & corrosive resistance
Precast of Non-Structural Units

• With a variety of products & design options, precast concrete units are widely used in the construction industry

• Geopolymer based materials (GpM) offers eco-friendly solution to the precast industry
A 6-storey office & retail building
Structural Use in China

Beams & columns of a workshop
Development of GpM in NAMI

• GpM formulation & optimization targeting different applications & collaborations
  - Alkalinity & types of activator
  - Chemical admixtures & inert fillers
  - Reactivity of raw materials such as metakaolin, slag, fly ash, clay, etc.
  - Functional materials

• Physical, chemical, fresh & hardened properties, durability & micro analysis

• Different forms in paste, mortar, concrete & fiber reinforced GpM
Nano Modification

• Nano-particles to be utilized for micro-strengthening
  ➢ Carbon nanotube, nano clay, nano silica, etc.

• A realistic molecular structural model to be established facilitating further development
Materials Characterization

• Particle size distribution
• Phase identification (XRD)
• Surface morphology (SEM)
• Calorimeter (reaction heat)
Surface Morphology

Ordinary Portland Cement

Ground granulated blast-furnace slag

A cluster of fly ash

The spherical shell structure
Early Strength for Rapid Repair

- Facility can be re-open within several hours
Acid Resistance of GpC

- Residual strength after 14-day acid attack
  - GpC (54 MPa) / cement paste (39 MPa)
The C-A-S-H gel

- Aluminate species strengthened silicate chains & transform layered structure to 3-D network
- Enhancing the stiffness of C-S-H gel
Strengthened Interlayer Region

Al/Ca=0.08

Al/Ca=0.38
Concluding Remarks

• Contributing to the sustainable development, geopolymerisation is a **green technology**
• Utilizing metakaolin, slag & fly ash, geopolymer is a prominent **alternative cement**
• Demonstrating the capability of **early strength development & excellent chemical resistance**
• Geopolymer based material **can be customized for different applications**
Ongoing Research Works

• Characterizing functional admixtures for & optimization of GpM for different applications
• Identifying long term & stable supply of quality raw materials
• Commercialization & promotion of geopolymer based materials in HK
• Collaborations with universities/ institutes and industries are welcome
• Graduates with related background are strongly welcome to join us
Thank You Very Much!

Let’s unleash world-class technologies to benefit your growth.