

Functional Construction Materials Laboratory

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DEPARTMENT OF
CIVIL AND ENVIRONMENTAL ENGINEERING
土木及環境工程學系

Opening Minds • Shaping the Future
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Introduction

This laboratory focuses on functional construction materials' researches. It also equips with tools that facilitates sample preparation.

For Sample Preparation

- > Buehler CAST N' VAC 1000 Vacuum System
- > Buehler MetaServ 250 Grinder-Polisher
- > Buehler AutoMet 300 Grinder-Polisher
- > Buehler High Speed Pro Precision Cutter
- > Labconco FreeZone 2.5 Liter Benchtop Freeze Dryer
- > Shellab Vacuum Oven

For Advanced Research

- > AMETEK Brookfield RST Coaxial Cylinder Rheometer
- > DC Power Supply & Power Meter
- > IKA Overhead Stirrers RW 20 digital
- > Metrohm Multi Autolab/M204 - Multi Potentiostat/Galvanostat
- > Plasma Enhanced Chemical Vapor Deposition System
- > Solar pyrometer
- > SHEL LAB CO2 Incubator
- > Smart Weather Station
- > Ultra violet weathering chamber
- > Xenon lamp weathering chamber

Main Equipment



**AMETEK Brookfield
RST Coaxial Cylinder Rheometer**

Rheological evaluation through controlled stress and controlled rate measurements offer superior viscosity profiling, thixotropic response, yield stress determination and creep analysis.



DC Power Supply & Power Meter

The DC power supply is equipped with a high-resolution power meter to accurately measure the output power intensity. This system can be used to measure passive radiative cooling power of small-sized coating samples.

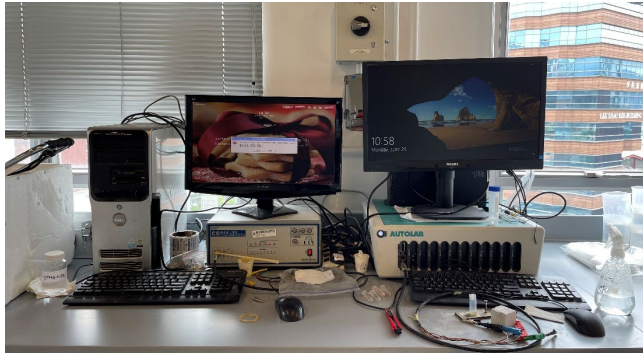
The power meter can also be used to monitor the energy consumption changes of a system (e.g. air conditioning energy consumption of a house)



**IKA Overhead Stirrers
RW 20 digital**

The overhead stirrers is capable for universal use from 60 to 2000rpm speed. It can stir samples quantities of up to 20L H₂O.

Main Equipment



Metrohm Multi Autolab/M204 – Multi Potentiostat/Galvanostat

This is a multi channel potentiostat/galvanostat based on the compact Autolab PGSTAT204. It consist of a Multi Autolab Cabinet which can be fitted with up to 12 M204 modules.

Each M204 is a completely independent potentiostat/ galvanostat, which allows users to perform different measurements on each channel at the same time.



Solar Pyrometer

EKO MS-802 Solar Pyrometer is a reliable reference sensor for measuring the solar radiation with high precision (covers light wavelength range of 285-3000nm, with the measure accurate of $\pm 6W/m^2$).

It is used as a standard in PV research and climatological studies. The pyranometers provides a unique calibration compliant to the international standards defined by ISO9847.



WS601-UMBSmart Weather Station

The Smart Weather Station is a compact all-in-one weather sensor with measurement of temperature, relative humidity, precipitation, air pressure, wind direction and wind speed.

Functional	Measuring range	Precision
Temperature	-50 --- 60 ° C	$\pm 0.2^\circ$ C
Humidity	0 --- 100 % R.H.	$\pm 2\%$ R.H.
Air pressure	300 --- 1200 hPa	± 0.5 hPa
Wind direction	0 ---359.9 °	$< 3^\circ$
Wind speed	0 ---30 m/s	$\pm 0,3m/s$
Precipitation		$\pm 2\%$

Main Equipment



SHEL LAB CO2 Incubator

This CO2 Incubator serve a wide range of bacterial and cell growth applications using innovative technology to ensure uniform temperature and humidity levels within small error margins.



Ultra violet weathering chamber

This chamber uses UV as the light source to fully simulate UV light in sunlight spectrum for providing corresponding accelerated test for scientific research, product development and quality control.

As UV-exposure is the most aging inducement for polymer macromolecules, it is important for characterizing the long-term durability of coating materials.



Xenon lamp weathering chamber

This chamber uses xenon arc lamp to fully simulate sunlight spectrum and cycled spaying-blowing-drying system for providing corresponding accelerated test for scientific research, product development and quality control.

The instrument satisfies relevant standard testing methods ASTM C 1442-14. It can fully cover UV to Vis range (300nm-800nm), with average radiation power at this range of no less than 500 W/m² (half of AIM 1.5)

Main Equipment

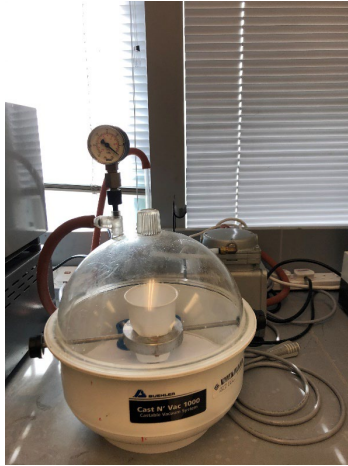


Plasma Enhanced Chemical Vapor Deposition System

The plasma enhance chemical vapor deposition (PECVD) system is designed for two-dimensional nanomaterials synthesis such as the graphene and carbon nanotube (CNT).

The system includes a high-temperature tube furnace with the temperature up to 1400 Celsius, four mass flow controllers for gas delivery, liquid nitrogen cold trap for moisture elimination, air bubbler for liquid phase precursor delivery and a plasma source for pretreatment of the gas precursor to achieve lower reaction temperature. The system is capable of graphene, CNT, MoS₂, and other 2D nanomaterials synthesis.

Main Equipment



Buehler CAST N' VAC 1000 Vacuum System

This castable mounting vacuum system for epoxy offers pore impregnation in a compact format. It removes trapped air from mounting material and fills voids in the specimen.

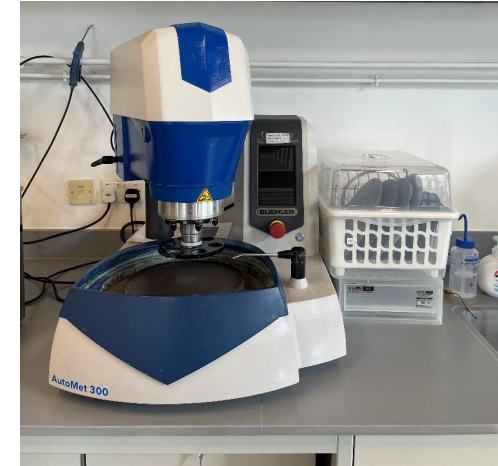
This enhances edge retention and supports delicate and friable samples.



Buehler MetaServ 250 Grinder-Polisher

AutoMet 250 is designed for manual or automated sample grinding and polishing for most microstructural analysis application.

A built-in bowl wash and drain flush out particles and minimizes build-up of grinding-polishing debris.



Buehler AutoMet 300 Grinder-Polisher

AutoMet 300 is designed for manual or automated sample grinding and polishing for most microstructural analysis application.

A built-in bowl wash and drain flush out particles and minimizes build-up of grinding-polishing debris.

It is upgraded to a color touch-screen control panel for Z-axis material removal by depth.

Main Equipment



Buehler High Speed Pro Precision Cutter

A table top precision saw that provides efficient and precise cuts with intuitive control. It aligns cuts quickly by using the precision laser. It has a blade motor power of 2kW, which ensures the blade will minimize the deformation of the sample surface.



Labconco FreeZone 2.5 Liter Benchtop Freeze Dryer

FreeZone Freeze Dryers are designed to handle the lyophilization needs of research laboratories. The freeze-drying technique is a dehydration operation in which water in frozen substances is removed by sublimation from ice to vapor.



Shellab Vacuum Oven

The vacuum oven enables samples to be dried and stored under vacuum condition. In the oven-drying process, the phase change of water by usual drying occurs.

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Research Spotlight

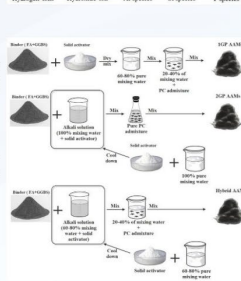
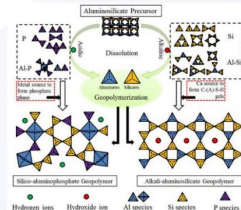
Low-carbon Geopolymer Cementitious Composites

Low-carbon Geopolymer Cementitious Composites

- Global warming and climate change are huge concerns worldwide. Hong Kong has promised to achieve carbon neutrality before 2050. Since the cement industry is one of the major contributors to global warming, clinker-free cement, which is also referred to as geopolymer or alkali-activated material (AAM), is one of possible solutions to lower greenhouse gas emissions and help to achieve carbon neutrality.
- Production of geopolymer concrete can lead to a reduction of CO₂ emissions by 50%-80% and require 60% less energy compared with that of conventional ordinary Portland cement (OPC) concrete.
- Geopolymer is manufactured through chemical activation of aluminosilicate precursor materials, either naturally available such as metakaolin or from industrial byproducts like fly ash or slag (termed as "precursor"), using acidic or alkaline agents (labeled as "activator").

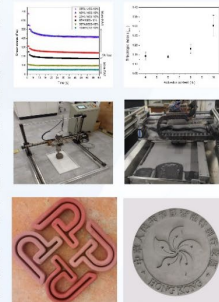
Terminology and mixing approaches

- Alkali-aluminosilicate geopolymers or silico-aluminophosphate geopolymers based on the activation process of aluminosilicate sources under alkaline or acidic conditions.
- C-(A)-S-H gels and/or N-A-S-H gels are dominant in alkali-aluminosilicate geopolymers.
- S-A-P gels dominate silico-aluminophosphate geopolymers.
- Production of geopolymer can be achieved following either "one-part" terminology (solid activators) or "two-part" system (liquid activators).
- The one-part or "just-add-water" geopolymer has excellent potential in practice due to its simple operation (simply mixing water with the readily-mixed binder).
- The one-part geopolymer can be produced as distributive bagged material, enabling convenient storage, safe transportation, and mass production.
- The technology of superplasticizers is still under development.



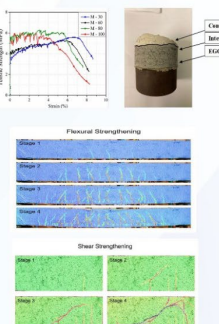
Additive manufacturing (3D printing)

- Rheology and thixotropy of one-part geopolymer are the controlling factors.
- The 3D printing in construction is usually carried out by means of an automated, selective, and layer-by-layer deposition of cement-based materials through extrusion or powder-bed/inkjet technology, which may be a potential game-changer in the construction industry.
- Successful 3D printing examples of one-part geopolymer using extrusion and powder-bed/inkjet technologies.



Repair material

- Using the one-part geopolymer cement, high-performance mortars can be achieved and implemented as repair materials.
- By the addition of fiber reinforcement, super ductile engineered geopolymer composites (EGC) can be developed.
- Geopolymer mortar possesses excellent bond strength with OPC concrete and can be used for rehabilitation and strengthening.



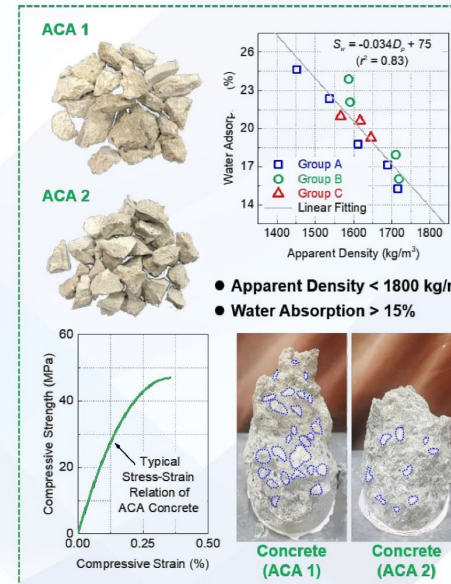
Functional Artificial Aggregates for Sustainable Construction

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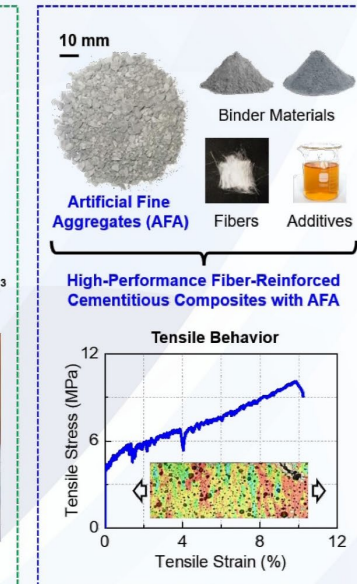
Aggregates occupy most volume of concrete materials. Shortages of natural aggregates (sand and gravel) nowadays become a critical problem for concrete industry because of the unprecedented scale of construction activities. The large-scale excavation of natural aggregates has also severely imposed a threat onto natural environments.

Artificial aggregates can be produced from industry by-products/urban wastes that increase annually through the sintering or cold bonding technology. Manufacturing artificial aggregates provides a one-stone two-birds solution to the above-mentioned problem. Cost-effective methods are being explored here to produce both coarse and fine artificial aggregates with large-quantity, which can be also functionalized with different physical, mechanical and chemical properties during the manufacturing, to enable production of high-performance cement & concrete composites.

Artificial Coarse Aggregates (ACA) for Ordinary Concrete



Artificial Fine Aggregates (AFA) for High-Performance Cementitious Composites

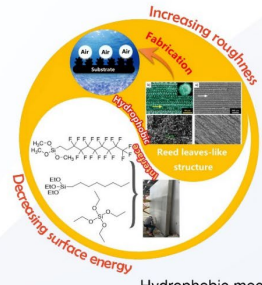


Research Spotlight

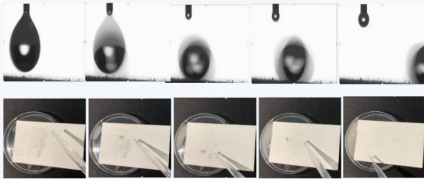
Eco-friendly and Multifunctional Concrete Coatings

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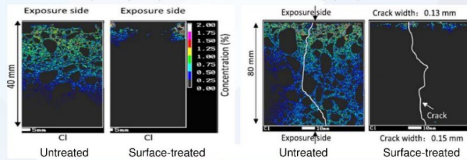
Surface coating is a most cost-effective means which can isolate concrete buildings and infrastructure from hostile service environments. Research efforts here are being devoted to the development of eco-friendly and multifunctional concrete coatings mainly from the following two aspects: (1) Creating a super hydrophobic/self-cleaning surface by chemical modification and micro-/nano-structure fabrication, to improve the durability of concrete structures and reduce the life-cycle maintenance cost; (2) Achieving a daytime sub-ambient radiative cooling effect for reducing building energy consumption and mitigating the urban heat island effect.



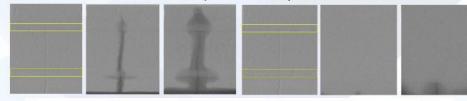
Hydrophobic mechanisms



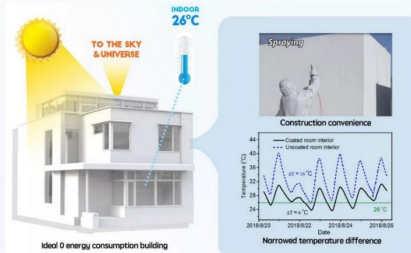
Super-hydrophobic and self-cleaning properties



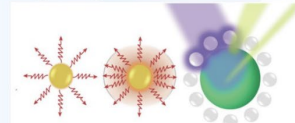
Chloride penetration profiles



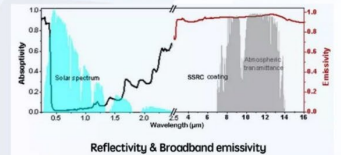
Water penetration profiles



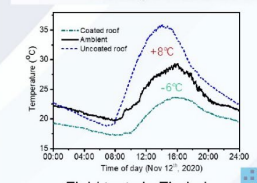
Energy-saving and sub-ambient radiative cooling



Purcell effect & enhanced fluorescent emission



Reflectivity & Broadband emissivity



Field tests in Zhuhai

Carbon Neutral Construction Materials

Carbon Neutral Construction Materials



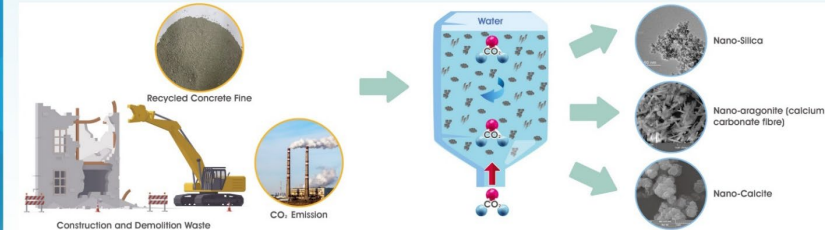
Capture and storage of CO₂ by construction and demolition waste

- Coarse recycled aggregate derived from recycling construction and demolition waste can sequester CO₂ to densify its microstructure. Adopting such technology can enhance the strength and improve the dimensional stability of recycled concrete products.



Converting concrete wastes to green nano-construction materials

- Recycled concrete fines derived from recycling construction and demolition waste can be converted to green nano-silica and nano-calcium carbonate. These nano-construction materials can enhance the mechanical properties and durability of new concrete.



Benefits

- Recycling of construction and demolition waste
- CO₂ capture and storage by construction and demolition waste
- Enhancement of new concrete products by CO₂ sequestration
- Production of green nano-construction materials

Lab-in-charge and Technical Staff



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(excluding Saturday, Sunday & public holidays)