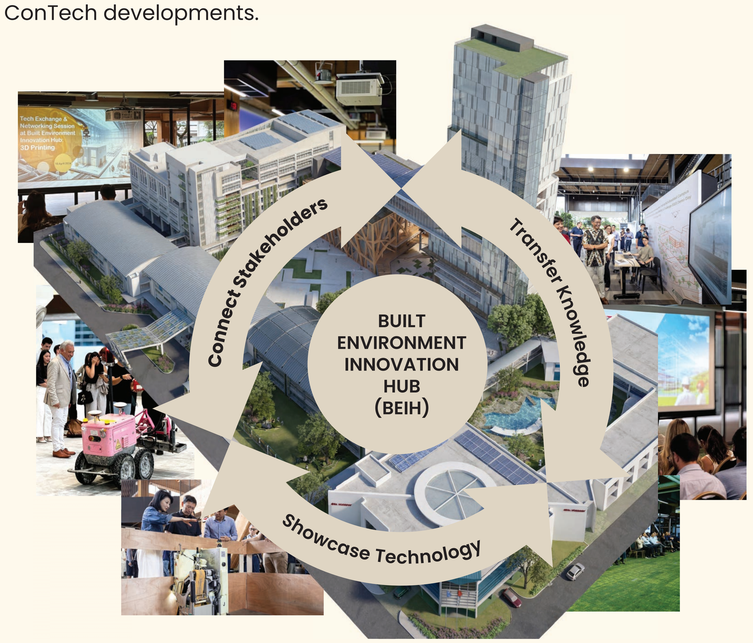
BUILT ENVIRONMENT INNOVATION HUB (BEIH) AT BRADDELL CAMPUS

Launched in Oct 2023, the BEIH located at BCA Braddell Campus has established itself as the nexus of BE innovation – where industry stakeholders converge to connect with one another, showcase promising solutions, and transfer knowledge on the latest ConTech developments.



Regular Tech Exchanges Organised In 2025

In 2025, events organised under the BEIH involved **more than 600 stakeholders and 42 unique I&T solutions**, creating **more than 150 connections** between event attendees.

SPACES AVAILABLE AT BCA BRADDELL CAMPUS

Demonstration Spaces

To showcase the latest technologies supporting the Built Environment Industry Transformation Map (BE ITM)

Supported by 19 progressive tenants who actively pursue Innovation & Technology collaborations

Event & Training Spaces

To connect industry stakeholders through partnerships, and transfer knowledge aligned to the BE ITM

One such partnership was the establishment of Obayashi Construction-Tech Lab Singapore (OCLS) as Obayashi's regional R&D outfit at BCA Braddell Campus

ADVANCED CONSTRUCTION

PILOT IMPLEMENTATION OF CAST IN-SITU CONTINUOUS "CONFLEXPAVE" BENDABLE CONCRETE PAVEMENT IN SINGAPORE

Funded by: **JTC (I3C)**
Lead PIs: **Assoc Prof Yang En-Hua (NTU), Prof Bernard Lechner (TUM), Dr Ali Aryo Bawono (TUM), Mr Ng Kian Wee (JTC)**
Stakeholders involved: **JTC, NTU, TUM Create**

ConFlexPave is a high-performance fibre-reinforced cementitious composite with extreme tensile ductility several hundred times that of normal concrete. With high flexural strength and superior fatigue resistance, the pavement thickness can be reduced by 50% while doubling the service life and reducing the maintenance frequency, resulting in more than 50% life cycle cost reduction.

An existing access road to a JTC facility exhibited latent defects, including signs of structural cracking and plastic deformation (Fig. 1). During investigation (Fig. 2), it was found that base and subbase layers were having uneven thickness. Furthermore, telecommunication concrete haunches have been constructed in a few segments under the base layers resulting in even thinner base/sub-base layers (Fig. 3). Despite low traffic volume, heavy vehicles with much higher axle loads than passenger cars frequently use this road, contributing to its deterioration.

Fig. 1

Fig. 2

Fig. 3

The ConFlexPave was mixed using four mixers in two batching plants (Fig. 4). Continuous casting of 60 m³ ConFlexPave was completed within 8 hours (Fig. 5 and 6).

Fig. 4

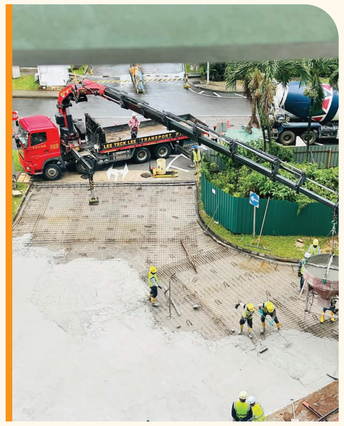


Fig. 5

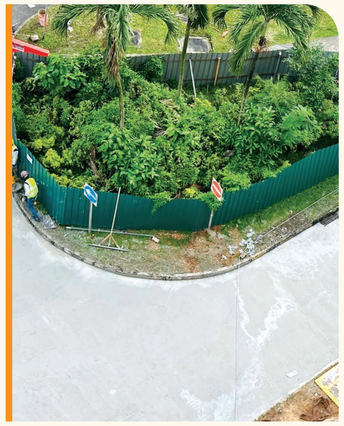


Fig. 6

The following day, surface treatment was conducted to improve the surface, resulting in high skid resistance road (Fig. 7 and 8). Wet curing using burlap was done for at least seven days (Fig. 9).

Fig. 7

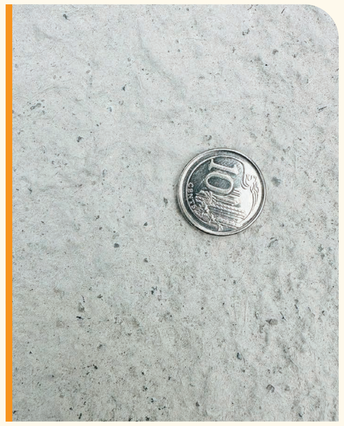


Fig. 8

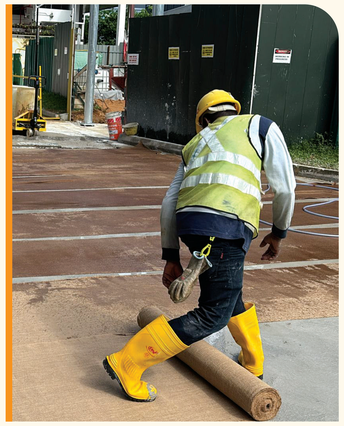


Fig. 9

ADVANCED CONSTRUCTION

AN INTEGRATED GEOPHYSICAL AND GEOTECHNICAL METHOD FOR SINKHOLE DETECTION DURING BORED TUNNELLING

Funded by: **Cities of Tomorrow R&D Programme (CoT)**
Lead PI: **Assoc Prof Wu Wei (NTU)**
Stakeholders involved: **BCA, Tritech Engineering & Testing (Singapore) Pte Ltd, China Railway Engineering Equipment Group Co. Ltd. Singapore Branch**

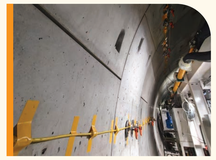
Over-excavation can occur during tunnelling due to improper excavation management and difficult ground conditions. Large voids due to over-excavation may cause sinkholes if not grouted in time. Investigations and grouting of voids are required when over-excavation is suspected but this process may take days and weeks. Space constraints for surface probing is also a challenge. Hence, there is a need to **develop a fast detection method for such over-excavation voids.**

An analysis software was developed for fast detection of over-excavation voids in front of the Tunnel Boring Machine (TBM) or from the surface using seismic scattering method. This method **overcomes the constraints of limited detection depth and poor image resolution of current geophysical methods, such as seismic reflection and ground penetration radar.** During the field tests, the solution has demonstrated the ability to detect pre-existing underground openings, be it within the TBM or from the surface, **successfully simulating the detection of tunnelling-induced anomalies and over-excavation voids.**

Trial tests were carried out at DTSS2 T10, Nicoll Highway Tunnel, West Coast Highway, CR109 and CR115 project sites. Illustration of how the test was setup inside the TBM to detect tunnelling-induced anomalies and over-excavation voids as shown below.

Electric spark

Geophone streamer on tunnel roof


Tunnel shoulder and sidewall

KEY ACHIEVEMENTS

Developed Ueyes Software for Coarse Detection of Underground Anomalies

Published 2 publications in Tunnelling and Underground Space Technology

(1) Smart detection of subsurface anomalies: Concept, validation and applications: Tunnelling and Underground Space Technology 154 (2024) 106107

(2) Intelligent detection of underground openings and surrounding disturbed zones: Tunnelling and Underground Space Technology 154 (2024) 106122

Paid Projects undertaken by NTU (post R&D)

- Scanning for cavities in limestone (DTSS Link sewer)
- Scanning for underground voids due to water ingress into tunnel (DTSS Link sewer)
- Scanning for underground voids at shaft due to water ingress (DTSS2)
- Scanning for underground voids due to anomalies detected in instrumentation reading (Cross-Island Line MRT project)

INTELLIGENT LIFTING FRAME (ILF) FOR PRECAST CONSTRUCTION

Funded by: **Cities of Tomorrow R&D Programme (CoT), Cool Ideas Enterprise (CIE) Programme**
Stakeholders involved: **HDB, NUS, A*STAR, Genios Pte. Ltd., Teambuild Engineering & Construction Pte. Ltd., Integrated Precast Solutions Pte. Ltd.**

The **Intelligent Lifting Frame (ILF)** integrates **advanced self-levelling, anti-sway stabilisation, and precise positional control** to deliver **faster, safer and more accurate on-site precast installation,** thereby enhancing overall construction productivity.

FROM RESEARCH TO PILOT-IMPLEMENTATION TRIAL

Research
Developed a full-scale intelligent lifting frame prototype

Commercialisation
Established a NUS spin-off, Genios, to translate prototype to actual system

Pilot trial
Ongoing pilot at a HDB BTO site through the Cool Ideas Enterprise (CIE) programme

Rigging and self-levelling

Anti-sway stabilisation during hoisting

Precision control & installation of precast components to the intended position

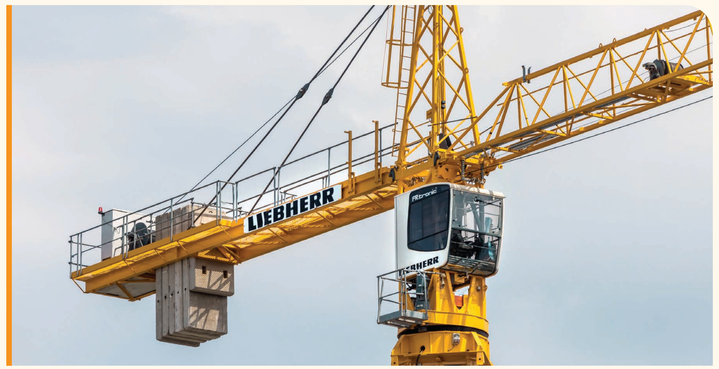
AI CRANE CABLE INSPECTION SYSTEM

Funded by: **Innovation Infrastructure Grant for Centre of Innovation - Built Environment Robotics & Automation (COI-BERA)**
Also funded under Temasek Polytechnic Research Fund
Lead PI: **Kok Yuan Yik (Temasek Polytechnic)**
Stakeholders involved: **Temasek Polytechnic, Capital Cranes Global Pte Ltd**

This project involves the development of an automatic AI crane cable inspection system to **enhance safety of construction crane operations** and to **improve the productivity of crane cable inspection.** It will enable continuous automatic real-time inspection of crane cable conditions in lieu of human monitoring.

This solution can potentially be applied to the **monitoring of other cable-based systems like elevator lifts and port cranes** to enhance the safety and resilience of these systems.

Vision System to Mitigate the Effects of Vibration on Image Quality



Prototype camera system which could be mounted based on the cable location (near the pulley system of the drum reel of the crane). It will be built using low cost cameras for 360° view of moving tower crane cable

Illustration of the image captured using the camera on top of a moving tower crane. Subsequent alerts could be sent to the system if anomalies are detected

ONGOING PROJECT PROGRESS

1. Licensed automated AI crane cable inspection system to Capital Crane Global Pte Ltd for testing and potential deployment

2. Hardware prototype built using low cost cameras to capture sharp and still images of moving crane cables for AI inspection

3. Ongoing development of AI inspection model and data collection

AUTOMATED TRACKING OF EARTHWORKS AND EARTH RETAINING AND STABILISING STRUCTURES (ERSS)

Funded by: **Built Environment Accelerate to Market Programme (BEAMP)**
Lead PI: **Ailytics**
Stakeholders involved: **Penta Ocean**

The project aims to develop an AI-based platform that harnesses **existing cameras on site to monitor machinery utilisation patterns,** including operating and idle times across work zones, workforce deployment and working hours. Benefits include **achieving 80% accuracy in detecting objects** (workers, excavators, dump trucks) **and activities** (work hours, licence plate recognition).

ADVANCED CONSTRUCTION

AUTONOMOUS CONCRETE FINISHING ROBOT (CFR)

Funded by: **MOF Reinvestment Fund (RF)**
Lead PIs: **Dr Chae Soungho (KaTRIS), Prof Yang Yao Wen (NTU), Dr Benjamin Ma (NYP), Mr Louis Lee (MPT), Mr Ng Kian Wee (JTC)**
Stakeholders involved: **JTC, Kajima Technical Research Institute Singapore (KaTRIS), NTU, NYP, Mega Plus Technology (MPT)**

This project developed an automated Concrete Finishing Robot (CFR) to improve productivity, quality and safety in concrete floor construction. Led by JTC and Kajima, with partners from NTU, Nanyang Polytechnic and local SME Mega Plus Technology, it addresses the sector's reliance on labour-intensive manual trowelling.

The CFR autonomously finishes concrete floors by sensing and interpreting the concrete hardening process in real time and adjusting its motion and finishing actions accordingly. This enables the robot to make complex judgements traditionally performed by skilled workers, while delivering consistent, high-quality flat floor finishes. A working prototype was successfully tested, demonstrating fully autonomous operation and remote monitoring from a central command centre.

Concrete finishing robot

Deployment at the construction of Kajima's new headquarters building achieved a 30% reduction in labour cost, validating the productivity benefits of the new workflow. The project also delivered key robotic and sensing innovations, including a data-driven digital twin that enabled safe simulation and optimisation of control algorithms, accelerating development while reducing cost and risk. The commercialised CFR is expected to increase productivity by up to 30% while reducing labour and construction time by a similar margin. Overall, the project demonstrates how close collaboration between government, industry and academia can transform labour-intensive construction workflows through automation.

SOFT CLAY-DERIVED AGGREGATE A.K.A ENGINEERED AGGREGATES (EA)

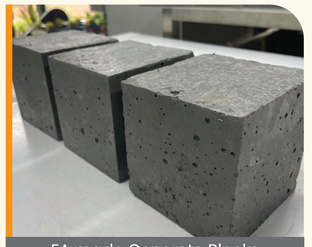
Funded by: **Cities of Tomorrow R&D Programme (CoT)**
Lead PI: **Dr Sun Xiaolong (Zerowaste Asia)**
Stakeholders involved: **BCA, Zerowaste Asia, Tuas Power**

This product made from local clay using Solidification–Immobilisation–Lithification (SIL) technology, supplemented with proprietary formula (consisting of chemical and industrial waste) is **environmentally safe**, **delivers 86% lower carbon emissions**, **28% better soundproofing**, **30% improved thermal insulation**, **and meets minimum structural lightweight concrete strength requirement**, with proven scalability.

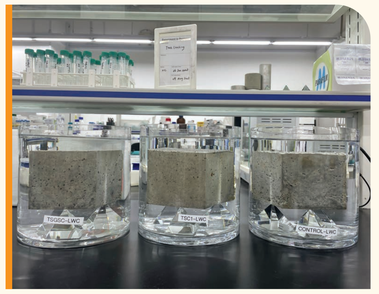
PROJECT ACHIEVEMENTS

Soft Clay

Engineered Aggregates (EA)


EA made Concrete Blocks

A patent has been filed under the project (Patent No. 10202302184Q).



The developed product achieved an 86% reduction in carbon footprint compared to a conventional Lightweight Aggregate (LWA) product.

A total of 100 m³ of soft clay was utilised to produce EA at an actual construction site. The EA products were used to fabricate a 1m³ concrete block, with the remaining material used as backfill.

ADVANCED CONSTRUCTION

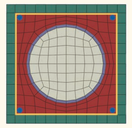
CONCRETE-ENCASED CONCRETE-FILLED STEEL TUBE (CECFST) COMPOSITE COLUMN

Funded by: **JTC (I3C)**
Lead PIs: **Prof Tan Kang Hai (NTU), Mr Ng Kian Wee (JTC)**
Stakeholders involved: **JTC, NTU**

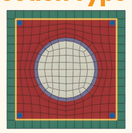
Concrete-encased concrete-filled steel tube (CECFST) composite columns combine a concrete-filled steel tube with an external reinforced concrete encasement, delivering high strength, stiffness and ductility while restraining steel tube buckling and enhancing fire and corrosion resistance. The external encasement facilitates efficient connections to both steel and concrete beams, making the system well suited for precast and prefabricated construction.

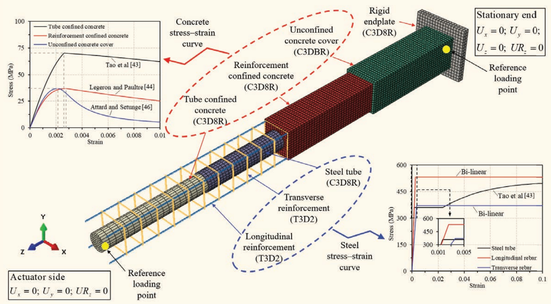
This project developed an innovative precast CECFST structural system supported by a comprehensive design guide, based on an integrated experimental and numerical research programme. Structural behaviour was investigated at cross-section level under axial, uniaxial and biaxial eccentric compression, and at member level for intermediate and slender columns. Long-term performance was addressed through dedicated studies on creep behaviour under sustained loading. To ensure practical implementation, a series of buildable connection solutions were designed and tested, including precast column-to-column dry connections, precast concrete beam-to-column wet and dry joints, and bolted steel beam-to-column joints assessed under cyclic loading.

Section Type A



Section Type B





Slender column numerical analysis

KEY ACHIEVEMENTS

Key outcomes include a CECFST Design Guide that bridges current code gaps and extends EN 1994-1-1 applicability, a unified column analysis method incorporating creep effects, and validated precast connection solutions demonstrating robust structural performance and constructability. Together, these outputs support safe, efficient and scalable adoption of precast CECFST systems in practice.

HYBRID MOUNTING BRACKET (HMB)

Funded by: **Korean Institute for Advancement of Technology (KIAT), Enterprise Singapore (ESG)**
Stakeholders involved: **JTC, BCA**

The Hybrid Mounting Bracket (HMB) is an advanced structural system developed to leverage and integrate the strengths of precast concrete (PC), steel, and prefabricated steel reinforced column (PSRC). The PSRC column is combined with steel angles to form a bracket, upon which a PC beam is placed. The assembly is then unified through concrete casting, resulting in a fully integrated structural connection.

One of the principal advantages of the HMB system is its efficiency: once the PC beam is lifted and positioned on the bracket, virtually no additional on-site work—such as bolting, welding, or extensive rebar placement—is required. **This significantly shortens construction time**.

KEY ACHIEVEMENTS

This project represents a significant international collaboration under the Eureka Network Projects, a flexible funding programme for R&D initiatives between 47 Eureka member countries. This partnership brings together Singapore organisations including JTC, BCA, KIMLY, SEN SG, and NUS, alongside four Korean companies. SEN Engineering Group of Korea has secured the design and construction contract for an ultra-large-scale development, which will implement PSRC columns and the HMB system across a site spanning approximately 98 football fields. The massive undertaking will require over 60,000 tonnes of steel and involve constructing approximately 3,000 columns using the innovative HMB system.

HIGH-PERFORMANCE COMPOSITE BEAM (HPCB) USING PRE-ENGINEERED S460 STEEL SECTIONS

Funded by: **B&I CentEx, MOF Reinvestment Fund (RF)**
Lead PIs: **Prof Chiew Sing Ping (SIT), Asst Prof Zhong Mingshan (SIT), Mr. Ng Kian Wee (JTC)**
Stakeholders involved: **JTC, SIT**

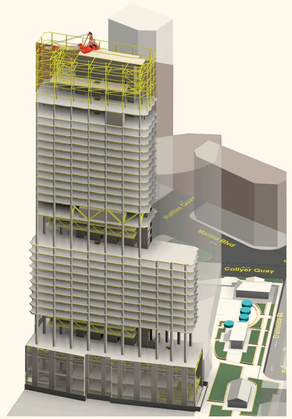
Sustainable construction depends not only on low-carbon and recycled materials, but also on smarter structural design that reduces material demand without compromising safety, resilience or adaptability. Aligning member geometry more closely with actual force demands offers a major opportunity to improve resource efficiency. To address this, the High-Performance Pre-engineered Steel–Concrete Composite Beam (HPCB) was jointly developed by JTC and the Singapore Institute of Technology.

The HPCB integrates a green concrete slab with an asymmetrical, high-performance steel section that is pre-engineered to match the force distribution in floor systems. By minimising redundant steel in the top flange and web, and ensuring the steel section remains predominantly in tension, the system achieves significantly higher structural efficiency than conventional solutions. Off-site fabrication further enhances build quality and construction speed.

Full-scale HPCB specimen demonstrating mechanical performance and constructability

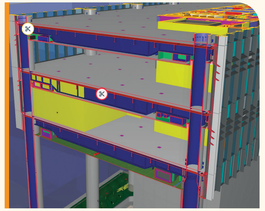
KEY ACHIEVEMENTS

A comparative case study against a traditional reinforced concrete floor system demonstrated approximately 41% reduction in embodied carbon, 14% improvement in construction productivity, and a 7.9% cost saving.



Architectural model of the Clifford Centre Redevelopment Project, where HPCB is deployed as the long-span flooring system

The HPCB has been adopted as the primary beam system for spans of up to 20m in the Clifford Centre Redevelopment, where it resolved headroom constraints, increased gross floor area, and reduced steel weight by 28.6% compared with the original design. The project confirms the robustness, scalability and industry readiness of the HPCB system.



Sectional view of HPCB

ADVANCED CONSTRUCTION

EDGE-AI VISION SYSTEM FOR HLA'S AUTONOMOUS FRONT-WHEEL LOADERS (AFWLS)

Funded by: **Innovation Infrastructure Grant for Centre of Innovation - Built Environment Robotics & Automation (COI-BERA)**
Also funded under Enterprise Singapore Enterprise Development Grant (EDG)
Lead PI: **Dr Li Yan (Ngee Ann Polytechnic)**
Stakeholders involved: **Ngee Ann Polytechnic, Island Concrete (subsidiary of Hong Leong), E&T Intelligence**

The Autonomous Front-Wheel Loader (AFWL), co-developed with E&T Intelligence Singapore Pte. Ltd. under the COI-BERA initiative, showcases innovation in the Built Environment through its use of an Edge AI vision system to **autonomously identify and load coarse and fine materials**.

Designed for Island Concrete Pte. Ltd., the system ensures optimal material blending for consistent concrete quality. Its deployment at the new S$200 million Ready-Mixed Concrete Ecosystem in Jurong Port demonstrates its practical impact in **boosting productivity**, **reducing manpower needs**, **and enhancing workplace safety**. This project highlights the **potential of AI-driven automation in transforming construction operations**.

An Autonomous Front Wheel Loader to be deployed at Island Concrete's latest batching plant within Ready-Mixed Concrete Ecosystem at Jurong Port with the Edge-AI system

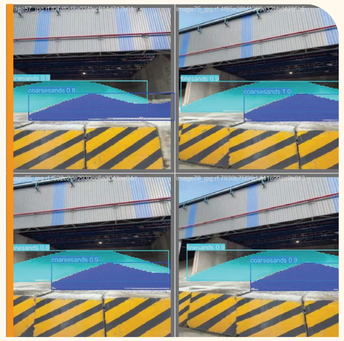


Illustration of how the AI model identifies coarse and fine materials

KEY ACHIEVEMENTS

NP developed edge AI vision model for material detection

E&T completed autonomous software development

Editorial Feature in IES Magazine

MULTI-PURPOSE OUTDOOR HEAVY-DUTY MATERIALS HANDLING FOLLOWER ROBOT

Funded by: **Innovation Infrastructure Grant for Centre of Innovation - Built Environment Robotics & Automation (COI-BERA)**
Also funded under MOE Decentralised Gap Funding (DGF)
Lead PI: **George Pan (Ngee Ann Polytechnic)**
Stakeholders involved: **Ngee Ann Polytechnic, Intelliseal Construction Pte. Ltd., Kajima Overseas Asia (Singapore) Pte. Ltd.**

This project presents an Autonomous Mobile Robot (AMR) developed to enhance material transport in complex and fast-paced environments. Outfitted with a camera-based vision system for precise worker tracking and a wireless remote for added control, the **AMR adapts seamlessly to dynamic workspaces**. Its modular payload includes a **rotating container and a forklift-trailer setup designed for easy attachment and removal to support a variety of transport needs**. With the ability to navigate uneven terrain and confined spaces autonomously or in follow mode, the **AMR improves workflow efficiency, reduces reliance on manual labour, and promotes a safer, more productive operational environment**.

Multi-Purpose Outdoor Heavy-Duty Materials Handling Follower Robot

ONGOING PROJECT PROGRESS

1. NP is working on the mobile platform procurement process.
2. Intelliseal is working with NP to develop auto loading/unloading system for the autonomous platform and weather-proof wireless controller for the mobile platform.

RESILIENT INFRA & SMART FM

INNOVATIVE ANTI-SLIP TREATMENT FOR FLOOR TILES

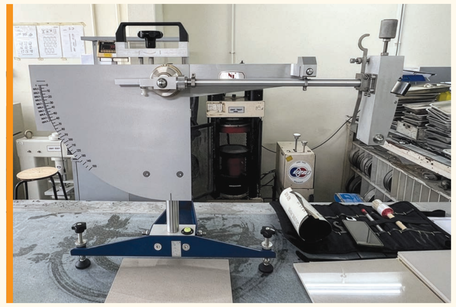
Funded by: **B-Team Construction Suppliers Pte Ltd, Innovation Infrastructure Grant for COIBE-AM**
Lead PIs: **Dr Xu Wenyu, Kevin Lee (Temasek Polytechnic)**
Stakeholders involved: **Temasek Polytechnic, B-Team Construction Suppliers Pte. Ltd.**

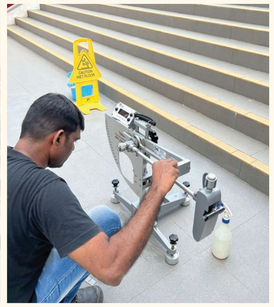
TP's innovative water-based anti-slip treatment, developed with B-Team Construction Suppliers, **significantly improves floor tile slip resistance in wet conditions** while meeting SS485:2022 standards. It offers **substantial cost savings through reduced maintenance downtime and labour costs** compared to conventional treatments.

The environmentally sustainable formula uses regional materials and produces zero Volatile Organic Compounds (VOC) emissions, minimising waste and environmental impact. The treatment has already proven its effectiveness through **successful implementation across residential**, **commercial**, **and private property projects**.

Performance Improvement

A **water-based treatment solution** has been developed to enhance surface grip on porcelain, ceramic, and other stone or mineral surfaces. This product interacts directly with the surface, **creating micro-structures that are invisible to the naked eye** while maintaining the natural look of the treated material. These micro-structures significantly **improve surface grip and reduce the risk of slipping in wet conditions**, whether the surface is accessed with footwear or bare feet.





COST & SUSTAINABILITY IMPROVEMENT

Zero downtime application compared to traditional anti-slip epoxy flake floor coating

Cost savings achieved through reduced materials and manhours required during application

WIRELESS STRUCTURAL HEALTH MONITORING (SHM) SYSTEM

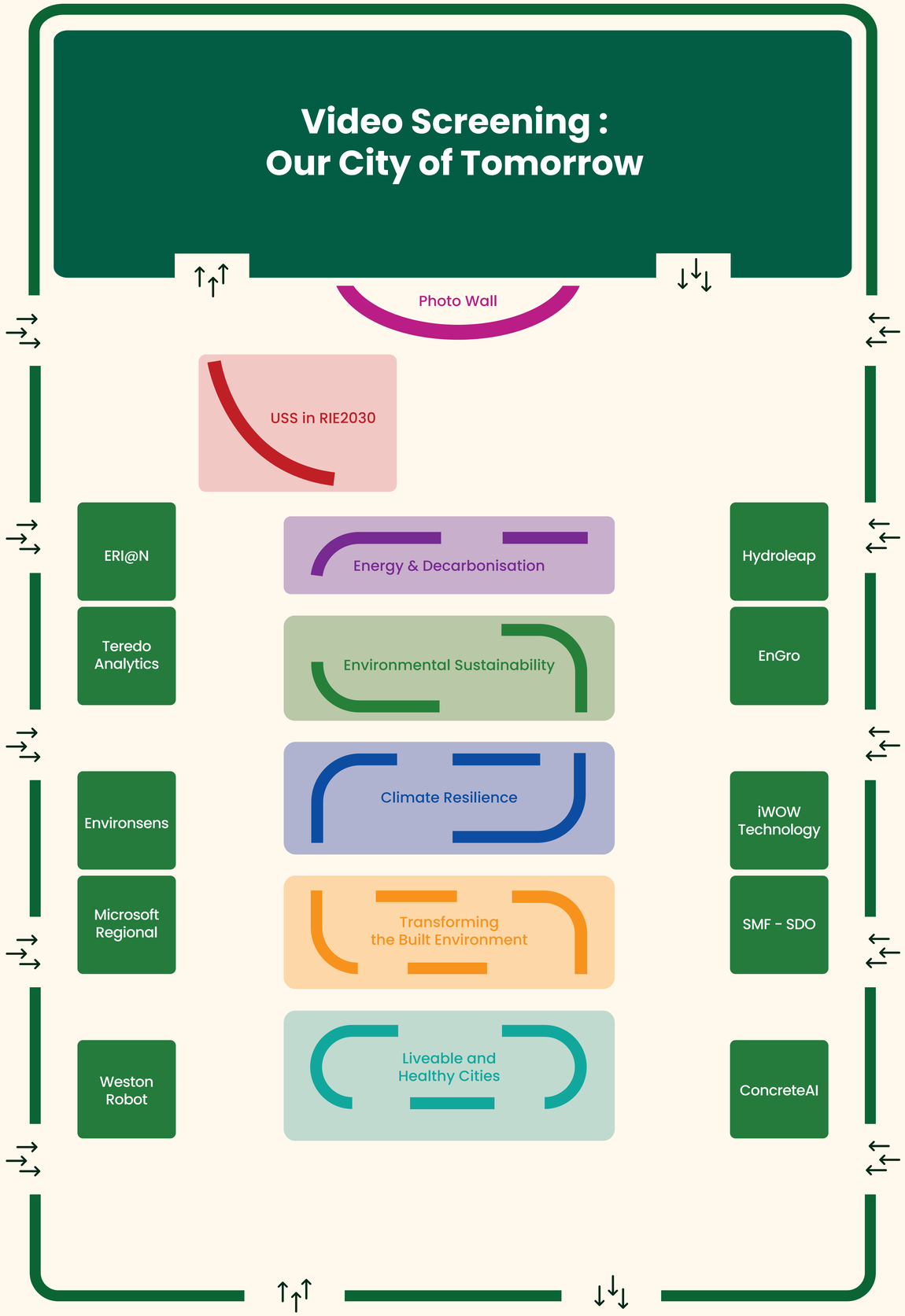
Funded by: **Cities of Tomorrow R&D Programme (CoT)**
Lead PI: **Dr Wang Yixin (A*STAR I²R)**
Stakeholders involved: **HDB, A*STAR I²R, NTU, Surbana Jurong Pte. Ltd.**

This project aims to develop a cost-effective and reliable **Structural Health Monitoring (SHM) solution** by utilising a **universal interrogator device to extract data from sensors** installed in HDB blocks. **The solution remotely monitors building structural conditions by automatically capturing, wirelessly transmitting and seamlessly visualising data**.

This automation has **significantly reduced data collection time by up to 90%,** resulting in a more **sustainable and efficient approach to managing building maintenance** while reducing manpower demands.

Example of SHM device installed in a HDB block

EXHIBITION FLOOR PLAN



RESILIENT INFRA & SMART FM

AUTONOMOUS INSPECTION OF RESIDENTIAL CORRIDORS

Funded by: **Built Environment Accelerate to Market Programme (BEAMP)**
Lead PI: **dConstruct Robotics**
Stakeholder involved: **EM Services**

The project aims to develop a robotic solution to **automate the inspection for defects and hazards in the common corridors of residential blocks** to reduce time and manpower required to conduct these routine inspections. **It has the capability to identify and classify building defects or hazards with 70% accuracy**.

Illustration of how a customised robotic solution could automate the inspection for defects and hazards in the common corridors of residential blocks

DEVELOPED CAPABILITIES

Generate 3D models through scanning of targeted residential blocks

Autonomously interface with lifts, use lifts, and navigate residential corridors

Develop analytics capability to identify and classify building defects / hazards with 70% accuracy

AN INTEGRATED SMART SOLUTION TO LIFT SAFETY MONITORING AND FAULT PREDICTIVE DIAGNOSIS

Funded by: **Cities of Tomorrow R&D Programme (CoT)**
Lead PI: **Mr Long Fei (SoftGridInc Pte. Ltd.)**
Stakeholders involved: **HDB, SoftGridInc Pte. Ltd.**

The Integrated Smart Lift Safety Monitoring and Predictive Diagnosis System comprises an **enhanced Lift Monitoring Device (LMD)** and a **remote lift monitoring solution** that continuously tracks lift performance through **sensors and analytics. Vibration patterns, acoustic signatures and operational data** are captured to **detect early fault signatures before breakdowns occur**, enabling **proactive maintenance** and improved **lift reliability**.

LMD ENHANCEMENT PROGRAMME

HDB implemented a technology refresh of the Lift Monitoring Device (LMD) to replace ageing hardware and strengthen long-term **maintainability and cybersecurity**. The programme replaced **10,000+ legacy LMDs islandwide in December 2025. SoftGridInc and Guthrie Engineering (local companies)** were awarded as **one of the enhanced LMD suppliers**.

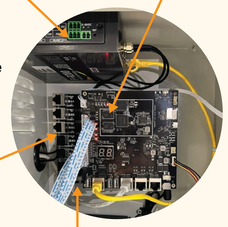
REMOTE LIFT MONITORING SOLUTION

The system has been **successfully implemented across lifts** through a partnership with Chevalier Singapore Holdings Pte. Ltd. It received regulatory approval through BCA's Remote Monitoring & Diagnostics sandbox trial, validating its effectiveness.

Enhanced LMD Key Innovations

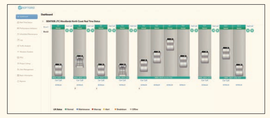
2-way Communication
with Tele-monitoring System (TMS) and HDB Smart Hub, enabling live data for analytics

Enhanced Maintainability
Supports over-the-air (OTA) firmware updates



Multi-lift Connectivity
One LMD can support up to 10 lifts (previously 1 LMD-to-1 Lift)

Open & Secure Communications
Non-proprietary interface with encryption and authentication for strong cybersecurity



Real-time dashboard showing lift operational states

Sensors installed on top of lift car to monitor lift performance

KEY ACHIEVEMENTS

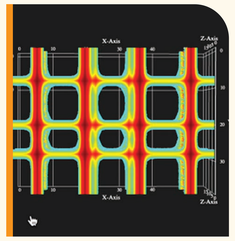
Field trials demonstrated measurable improvements:
- **Fault response time** decreased by 50%
- **Inspection efficiency** increased by 20%
- **Overall lift availability** improved by 10%

RESILIENT INFRA & SMART FM

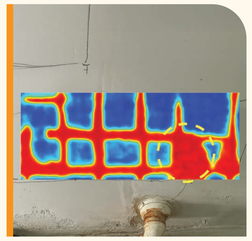
MICROWAVE SCANNING TECHNOLOGY FOR BUILDING MAINTENANCE

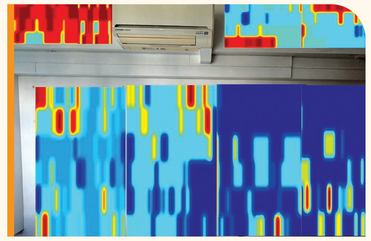
Funded by: **Cool Ideas Enterprise (CIE) Programme**
Stakeholders involved: **HDB, WaveScan Technologies Pte. Ltd.**

The microwave scanning tool is a first-of-its-kind for the Built Environment. It **non-invasively** maps subsurface moisture and **detects corrosion and spalling risks** before they become visible, enabling **proactive maintenance.**



Scanned image of healthy rebars


Signs of rebar expansion (Potential spalling concrete)


Scanned image of moisture presence

Microwave scanning at resident's unit

KEY ACHIEVEMENTS

Awards:

- IES Prestigious Engineering Achievement Awards 2025
- ASEAN Outstanding Engineering Achievement Award 2025

Interested parties can reach out to ***HDB_CoolideasENT@hdb.gov.sg*** for business enquiries or collaboration opportunities.

BIODIVERSITY ENHANCEMENT TILES FOR SUSTAINABLE AND DURABLE CONCRETE SEAWALLS

Funded by: **Cities of Tomorrow R&D Programme (CoT)**
Lead PI: **Assoc Prof Peter Alan Todd (NUS)**
Stakeholders involved: **NUS, HDB, NParks, Industry Partners (BunaBuna Pte. Ltd., Hyundai Engineering & Construction Co. Ltd., Surbana Jurong Consultants Pte. Ltd.)**

Coastal development, rising sea levels, increasing frequency and severity of storms are driving the expansion of coastal defences such as seawalls. As natural coastlines are progressively modified or replaced by these structures, the **loss of natural habitats had resulted in a decline in biodiversity.** While these structures primarily function as coastal defenses, they can be **ecologically engineered to introduce habitat complexity that enhances biodiversity on species-poor seawalls.**

The successful fabrication and retrofitting of BioBoss2 tiles has demonstrated that ecosystem complexity can be enhanced and optimised through engineered installations. The **20% tile density yielded the highest algal cover and species richness,** offering an optimal balance between biodiversity enhancement and constructability. This provides a **practical pathway for ecological upgrading of existing seawalls.**

1,500 BioBoss2 tiles installed along 1.125km of seawall in Singapore at **various densities** (i.e., 15%, 20%*, 25%, and 30%) across 10.8m sections forming **8 unique combinations** separated by 15m gaps. This creates the **world's largest biodiversity enhancement tile retrofit on a seawall to date**.

*20% tile density means 34 of 170 spaces on the seawall section were installed with BioBoss2 tiles.

Early algal colonisation supported diverse marine organisms, using BioBoss2 surfaces & cavities as habitat. Rough textured tiles may potentially promote micro-scale recruitment, which may influence community structure over longer timescales.

VALUE-ADDED USE OF WASTE GLASS TO MAKE SUSTAINABLE AND DURABLE CONCRETE

Funded by: **MOF Reinvestment Fund (RF)**
Lead PI: **Dr. Du Hongjian (NUS)**
Stakeholders involved: **JTC, NUS**

This project demonstrated the technical feasibility of utilising locally generated waste glass in the production of low carbon concrete. At a 20% cement replacement rate, the new material can achieve strength comparable to conventional concrete, with enhanced durability, ~14% embodied carbon savings, and ~6% cost savings.

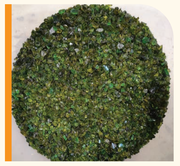
Pilot trials further tested the developed waste glass concrete in actual construction environments for both structural elements (ground-level slab) and non-structural applications (footpath), showing satisfactory performance.

Developing Waste Glass Concrete

Waste glass

Crush using jaw crusher

After crushing



Small particles (2-4mm)

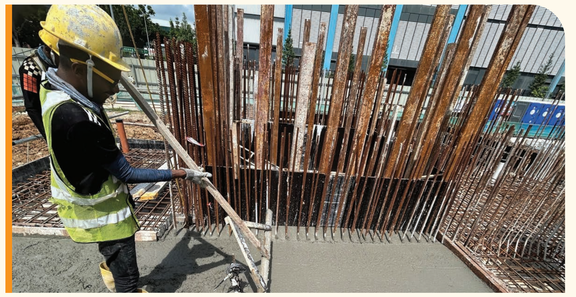
Mill using ball mill machine

After milling

Fine Powder

End sample

Replace 20% of cement in concrete production



Pilot trial of a ground-level waste glass concrete slab

Although challenges remain with industrial waste glass contamination and insufficient waste glass supply for mass concrete production, the project provides technical evidence for using waste glass in concrete applications, contributing to circular economy approaches in Built Environment sector through the conversion of waste materials into construction products.

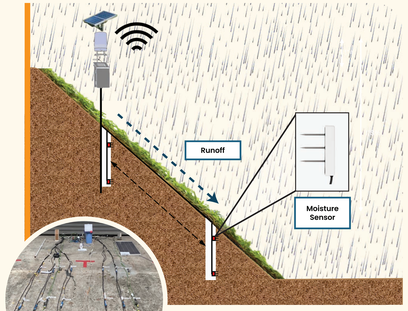
SUSTAINABLE BUILT ENVIRONMENT

ADVANCED MOISTURE SENSING TECHNOLOGY

Funded by: **Cities of Tomorrow R&D Programme (CoT)**
Lead PI: **Assoc Prof Leong Eng Choon (NTU)**
Stakeholders involved: **HDB, NParks, NTU**

The **Advanced Moisture Sensing Technology** is an **integrated IoT sensor system that enables real-time automated assessment** of both **slope stability and plant health.** The system utilises **relationships between soil moisture content and slope stability developed for Singapore,** as well as **relationships between moisture content and plant health** to convert soil moisture data collected by sensors **into interpretable assessments of both slope stability and plant condition,** providing continuous monitoring capabilities for slope and plant health management.

Implementation of system at testbed



Visual mock-up of the system

Real-time Monitoring Dashboard

Sensor system for the technology

TESTBED

The technology was **successfully deployed and validated** at a testbed site in Singapore, demonstrating its viability as a monitoring system capable of providing **proactive, real-time automated assessment of slope stability and plant health**.

A **guidebook was developed to provide guidance** for future users on the **installation, usage** and **management** of the system.

WASTE VALORISATION IN CONCRETE PRODUCTION VIA CO_2 SEQUESTRATION

Funded by: **Built Environment Technology Alliance (BETA) Catalyst Funding**
Lead PI: **Assoc Prof Zhao Ming Shan (SIT)**
Stakeholders involved: **BCA, SIT, Woh Hup, ConcreteAI, Cardiff University, IMRE**

This groundbreaking research developed an innovative aqueous CO_2 sequestration system for sustainable concrete production, addressing critical environmental challenges in construction materials. The technology utilises CO_2-enriched solutions to replace conventional mixing water, converting dissolved inorganic carbon into nano-sized calcium carbonate ($CaCO_3$) that becomes permanently integrated within the concrete matrix. This process enables **up to 80% replacement of Portland cement with ground granulated blast furnace slag whilst achieving 65% reduction in embodied carbon emissions**.

The system demonstrates superior cost-effectiveness with minimal operational overhead, enhanced concrete workability, and maintained structural durability. Through systematic research incorporating advanced characterisation techniques including scanning electron microscopy and thermogravimetric analysis, the team validated the technology's performance across multiple parameters. **The innovation directly supports Singapore's net-zero emissions targets by 2050** whilst addressing escalating infrastructure demands, representing a **paradigm shift towards circular economy principles in construction materials**.

KEY ACHIEVEMENTS

Structural concrete manufactured using the prototype carbonation system has been tested in 2 Executive Condominium (EC) projects (350m³) as illustrated below:

Carbonation system commissioned at Alliance Concrete Singapore Batching Plant

Use of structural concrete manufactured using the prototype carbonation system in Lumina Grand Arrival House

Won the IES Prestigious Engineering Achievement Awards (PEAA) 2024

TARGETS

- Early demoulding: 10-15 MPa within (12 – 24) hours
- Post-tensioning : 25 MPa within 3 days

SITE RESULTS

- 12 MPa compressive strength achieved onsite in 12 hours (monitored via ConcreteAI technology)
- Suggest potential for early formwork striking
- Enhanced durability and finishing texture

HYBRID-PASSIVE DISPLACEMENT VENTILATION AIR-CONDITIONING SYSTEM

Funded by: **Green Buildings Innovation Cluster (GBIC) - Product Prototyping**
Lead PI: **Kelvin Chay (YiTac Pte. Ltd.)**
Stakeholders involved: **BCA, YiTac Pte Ltd, Ngee Ann Polytechnic**

The Hybrid-Passive Displacement Ventilation (PDV) is a chilled water based air-conditioning system that uses high efficiency DC inverter compressor and plate heat exchanger to produce chilled water to serve passive displacement cooling coils, conventional fan coil units or air handling units. **The system can provide space cooling with zero or minimal air-side energy**. It adopts smart pumps to distribute chilled water to these air terminal equipment with very low pumping energy. **Testbedding results show that there is a potential energy savings of about 20%**.

As chilled water instead of refrigerant is circulated through the indoor space, it minimises the need for expensive and on-going leak detection system needed for direct refrigerant gas system. As the Hybrid-PDV system operates with chilled water, it will consistently provide comfortable, stable air temperature control during its operation.

Hybrid-PDV system is more suitable for cooling mid-size office buildings, hotels, hospitals, medical centres, schools, shopping centres and other commercial premises, where occupant comfort is paramount.

The solution was co-created by YiTac Pte. Ltd. with Ngee Ann Polytechnic-CfES.

YiTac's Hybrid Passive Displacement Ventilation AC System

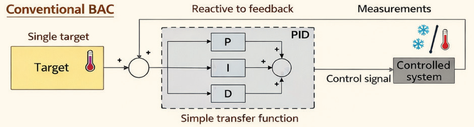
MODEL-PREDICTIVE CONTROL FOR SMART BUILDING ENERGY MANAGEMENT

Funded by: **Green Buildings Innovation Cluster (GBIC) - R&D**
Lead PI: **Assoc Prof. Wan Man Pun (NTU)**
Stakeholders involved: **BCA, NTU, PSA Corporation, Changi Airport Group, NTF General Hospital, JTC**

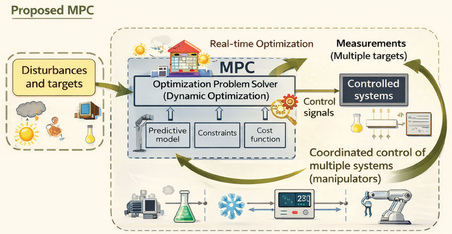
Conventional Building Automation and Control (BAC) systems lack the level of intelligence to coordinate the control of complex building systems to achieve multiple targets of energy efficiency and occupant well-being.

The Model Predictive Control (MPC) solution overcomes such limitations by employing a building model to **perform optimal, predictive and coordinated control of various building service systems including air-conditioning and mechanical ventilation**, **lighting (automated dimming) and shading (automated blinds and electrochromic windows)**, etc. The technology was testbedded in multiple buildings, **achieving 20 – 60% of energy savings while greatly improving occupants' thermal and visual comfort**. This solution is a game changer for the BAC market to shift to a much more intelligent level with predictive (instead of reactive) control and real-time optimisation.

Illustration of how the proposed MPC would optimise the control compared to conventional AC systems



Traditional BAC system with a Proportional-Integral-Derivative (PID) loop is a feedback mechanism used to maintain a desired setpoint (e.g., temperature, pressure, or flow rate)



A Model Predictive Control (MPC) system uses a dynamic model to predict future building behavior and environmental conditions to optimise energy efficiency and occupant comfort

The solution was developed by NTU with a start-up company created, NRGSense Technologies Pte. Ltd., to commercialise the technology to market.

SUSTAINABLE BUILT ENVIRONMENT

MAKING LOW-CARBON CONCRETE FROM CONSTRUCTION AND DEMOLITION WASTE

Funded by: **JTC (I3C)**
Lead PIs: **Dr Du Hongjian (NUS), Dr Yang Yi (NUS), Dr Liu Huawei (NUS)**
Stakeholders involved: **JTC, NUS**

Construction and Demolition Waste (CDW) represents a significant portion of Singapore's waste streams. In 2024, approximately 708,000 tonnes of CDW were produced, constituting 10.6% of the total solid waste generated locally. This project aims to investigate the feasibility of utilising CDW powder as a partial cement replacement in concrete production. The research involved developing cost-effective crushing and grinding processes to produce CDW powder suitable for cement substitution.

The CDW recycling process begins with primary crushing using a jaw crusher, followed by three cycles of crushing to break down materials into smaller fragments. The crushed material undergoes screening with a 3mm sieve to separate recycled aggregates and powder, which are then dried at 105°C for 48 hours to remove moisture. The dried recycled powder is processed through ball milling for 2 hours to achieve optimal particle size, followed by another screening stage with a 3mm sieve to produce Recycled Concrete Fines (RCF). The final concrete production involves mixing the RCF with coarse and fine aggregates, cement, and superplasticiser, then casting and compacting the mixture by vibration. After concrete curing, performance tests are conducted to evaluate the strength and durability performance of the RCF concrete.

1 Primary crushing

2 Secondary crushing

3 Screening with 3mm sieve

4 Drying

5 Ball milling for 2h

6 Sieve out to produce recycled concrete fines (RCF)

7 Mixing RCF with other concrete elements

8 Casting and compacting by vibration

9 Concrete curing

10 Performance test

KEY ACHIEVEMENTS

Based on the study, approximately 19% reduction in embodied carbon and 10% cost savings were achieved when replacing 20% of cement with CDW powder in concrete production, while maintaining comparable structural strength to conventional concrete.

GREEN BITUMEN

Funded by: **JTC Project Funding**
Stakeholders involved: **JTC, Samwoh, Vigcon Construction**

A greener bitumen, blended with locally processed Low-Density Polyethylene (LDPE) plastic waste, was deployed for internal road resurfacing at Block 28 Ayer Rajah Crescent. LDPE plastic waste poses a significant environmental challenge due to its slow rate of decomposition.

Traditional roads are constructed using bitumen, a black, sticky and highly viscous substance produced from the distillation of crude oil. By incorporating plastic waste into bitumen, this initiative helps divert plastic from incineration in Singapore. In addition to being eco-friendly, green bitumen offers several advantages.

1. Enhanced stiffness and durability: Laboratory tests indicate that green bitumen is 30% stronger and more durable than conventional bitumen, potentially reducing road maintenance frequency and costs.

2. Regulatory compliance: Field tests confirm that green bitumen meets all the regulatory requirements with respect to the engineering and environmental performance under actual traffic and weather conditions.

Deployment of green bitumen at Block 28 Ayer Rajah Crescent