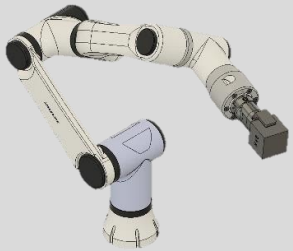
LSCM 2023 LOGISTICS SUMMIT 物流高峰會

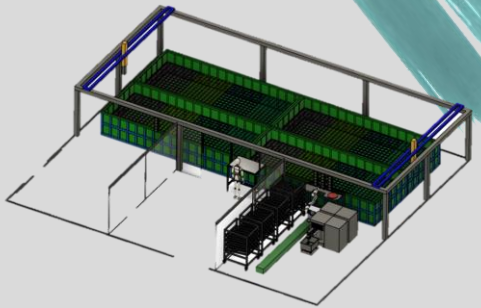
CEDD 土木工程拓展署 土力工程處 Geotechnical Engineering Office Civil Engineering and Development Department



Smart Public Works Laboratories - Automated Concrete Cube Testing System

Ir Dr Raymond W M CHEUNG, JP
Head of Geotechnical Engineering Office

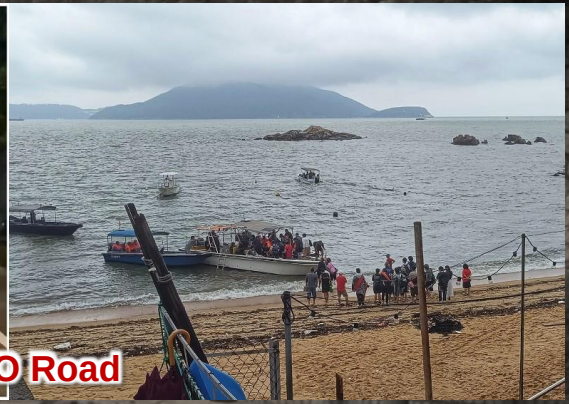
Geotechnical Engineering Office
Civil Engineering and Development Department

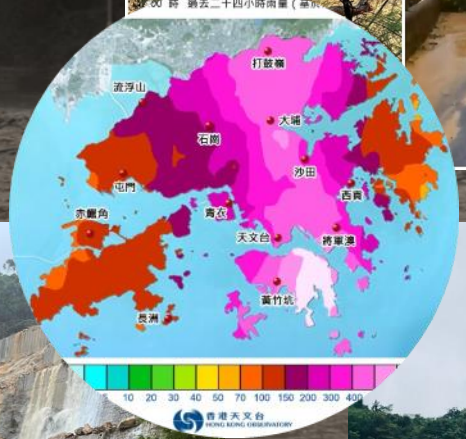


Landslides on 7 & 8 September 2023


Red Hill Peninsula


Shek O Road






Yiu Tung Estate


Cha Kwo Ling Village

Geotechnical Engineering Office
our services are expanding

Man-made Slope Upgrading & Landscape Treatment

Control of Geotechnical Works

Natural Terrain Landslide Risk Management

Landslide Emergency Services

Ground Investigation Geological Survey

Development of Geotechnical Standards & Guidelines

Public Education & Communication

Material Testing

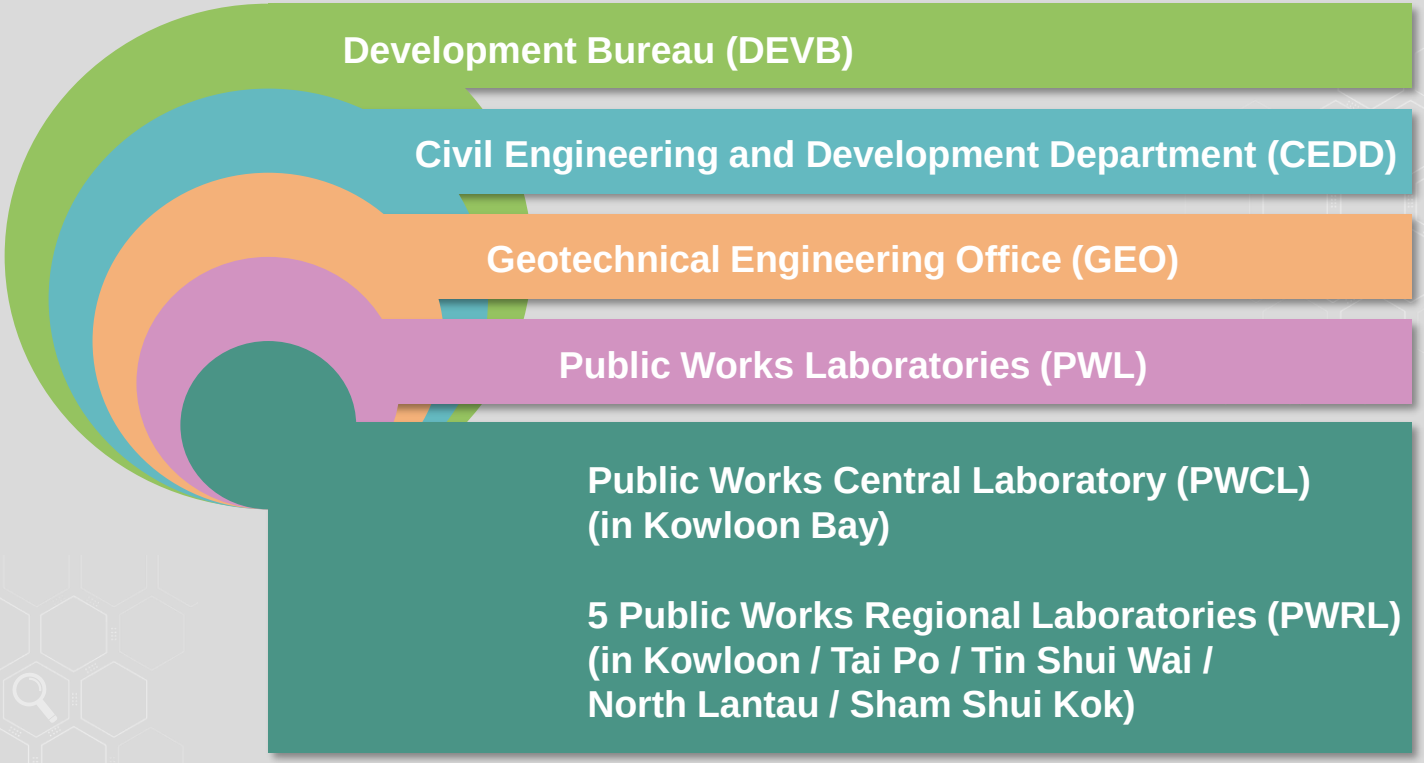
Prefabricated Steel Yard

Reclamation

Explosive Control
Quarry (Surface & Underground)

Cavern Development

Organisation



Material Testing Services

Forensic Testing

Provide testing services to forensic investigations conducted by Government Departments

Construction Materials Testing

Undertake construction materials compliance testing according to international and local standards

Setting Standards

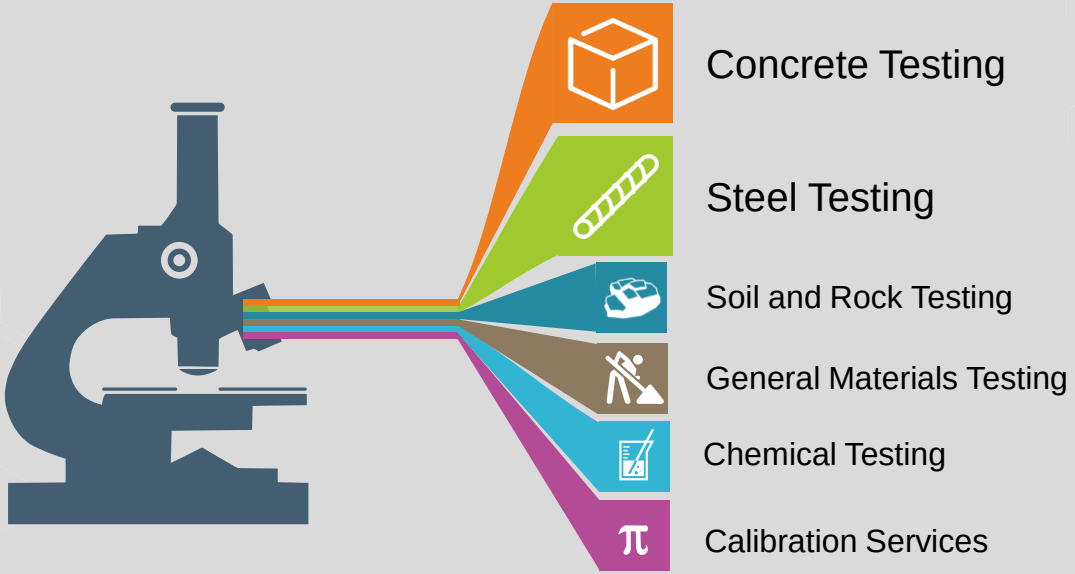
Develop and promulgate construction materials testing standards in collaboration with industry stakeholders

Research and Development

Explore and research into new construction materials and develop new testing techniques to meet the needs of construction industry

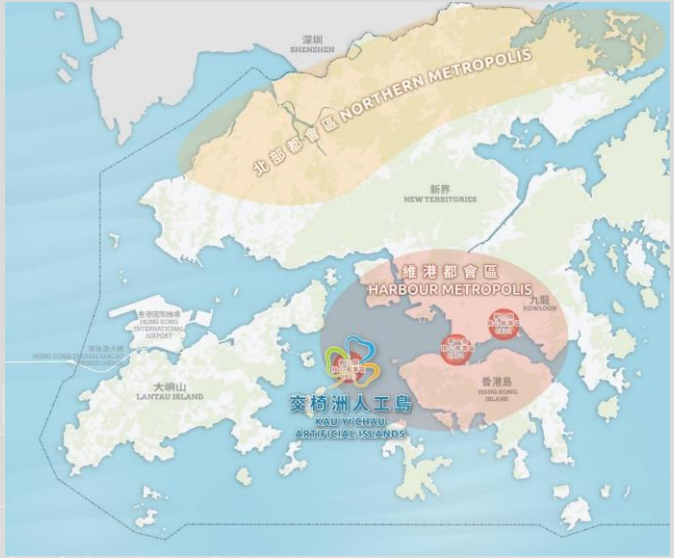
Construction Materials Testing

- Public Works Laboratories provides an extensive range of material testing services
- More than **600,000** tests for Government projects annually
- More than **200,000** concrete cube tests for Government projects annually
- More than **30,000** steel rebar tensile tests for Government projects annually
- More than **390** laboratory tests in our test directory

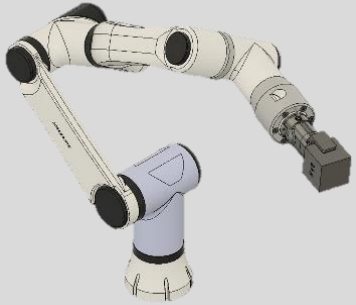


Pain Points

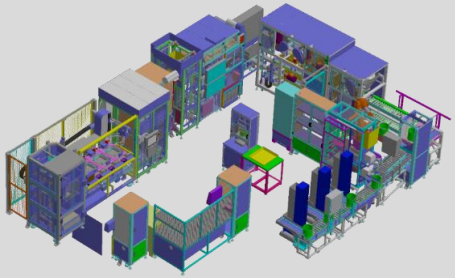
- **Increasing testing demand** to cope with upcoming expeditious infrastructure and housing developments
- **Manpower shortage** is becoming more serious
- Conventional test procedures are **tedious, repetitive and labour-intensive**
- Reliability of test results may be affected by **workmanship and human errors**
- Need to improve the **occupational safety and health** of laboratory staff



Human Error



Automated Testing Systems



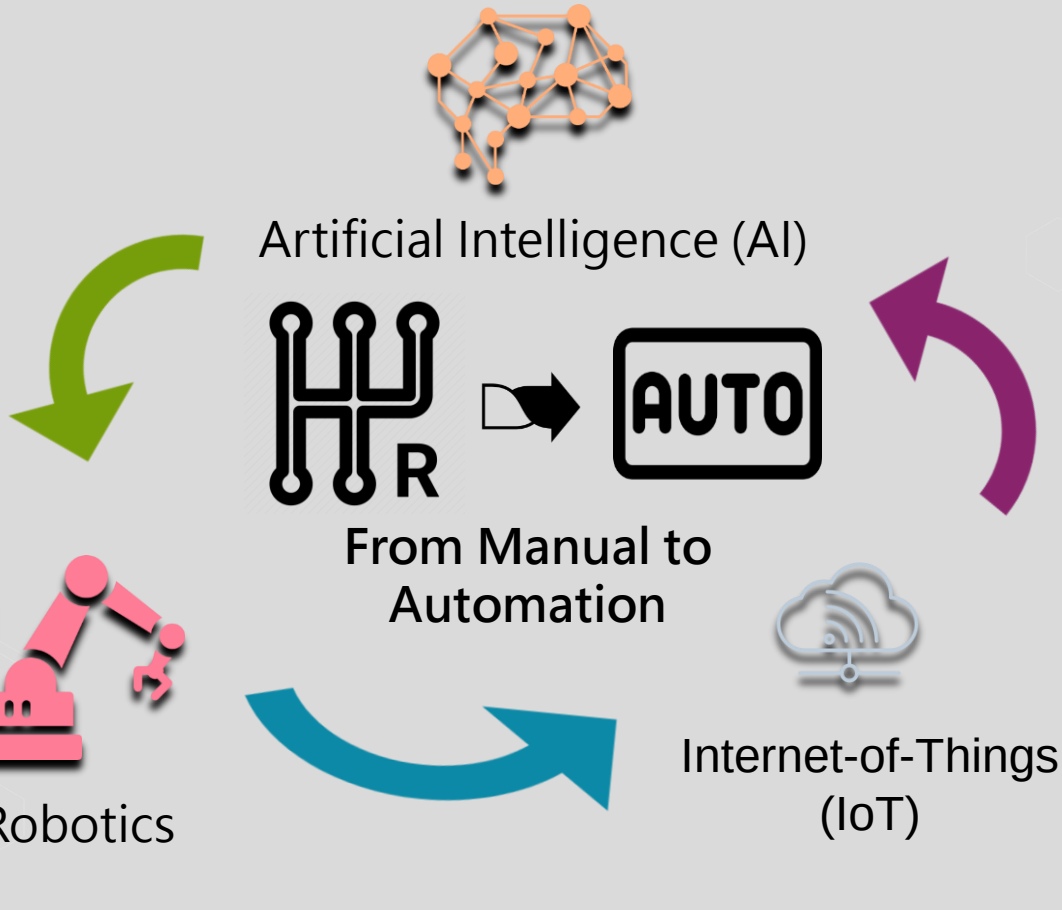
Market Research

- **No Automation Experience** in local construction materials testing industry
- In Dec 2017, we visited overseas laboratories with Automation Experience
  - Laboratory with **Automated Steel Rebar Testing System** in Germany
  - For steel rebar testing, the automation technology is mature
  - Laboratory with **Semi-Automated Concrete Cube Testing System** in Switzerland
  - For concrete cube testing, not a fully automated testing system (i.e. from curing to testing)

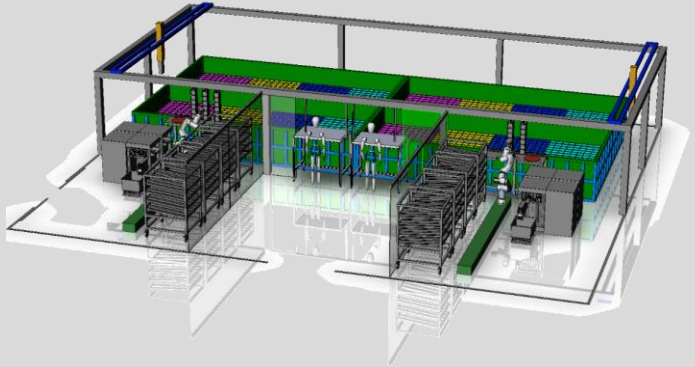
Pioneer Automation Systems

- **Concrete Cube Testing** and **Steel Rebar Testing** were selected as the pilot projects
  - Huge Test Demand (totally ~300,000 tests p.a.)
  - Critical to Structural Safety and Serviceability
- **Fill Compaction Related Testing (e.g. Proctor Compaction Test)** were also selected
  - Upcoming Expeditious Infrastructure Projects (Reclamation, Site Formation, Earth Filling)
  - Critical to Slope, Foundation and Reclamation Stability and Quality

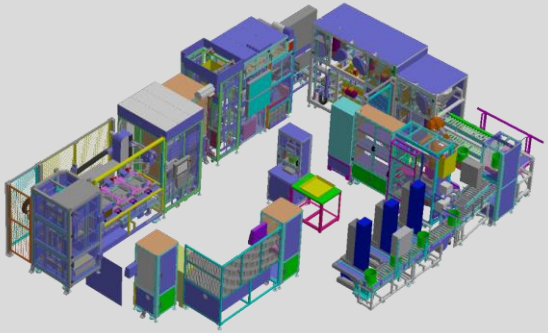
Adoption of Innovation and Technology



Automated Testing Systems



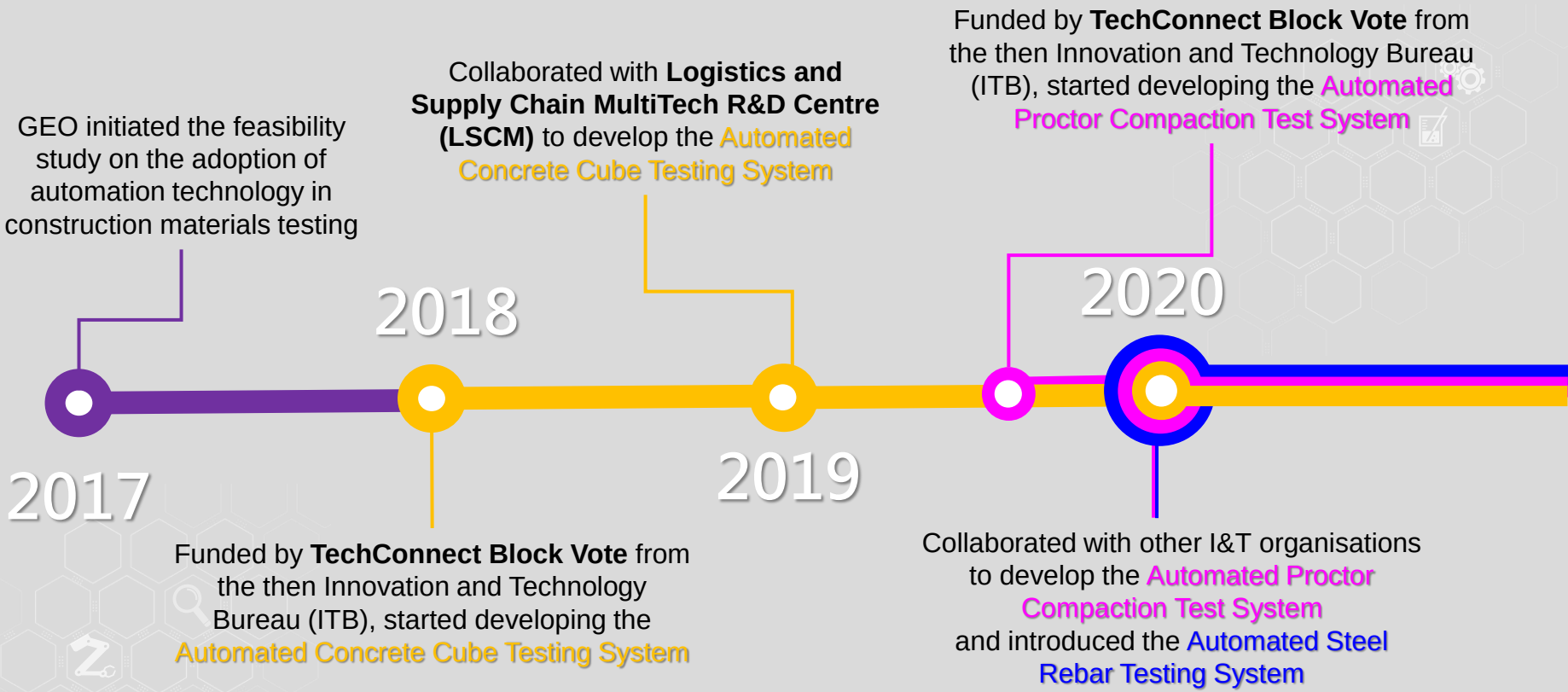
Automated Concrete
Cube Testing System



Automated Proctor
Compaction Test System

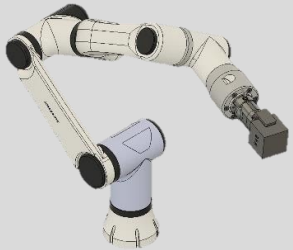
Automated Steel Reinforcing
Bar Testing System

Automated Testing Systems Development Process



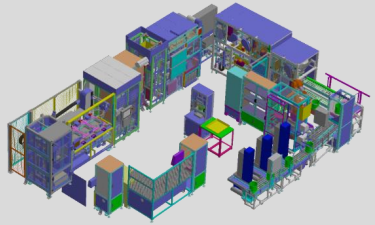
Automated Testing Systems Development Process

Automated Concrete Cube Testing System



Automated Steel Rebar Testing System

Automated Proctor Compaction Test System



Roll out of Automated Concrete Cube Testing System and Automated Steel Rebar Testing System

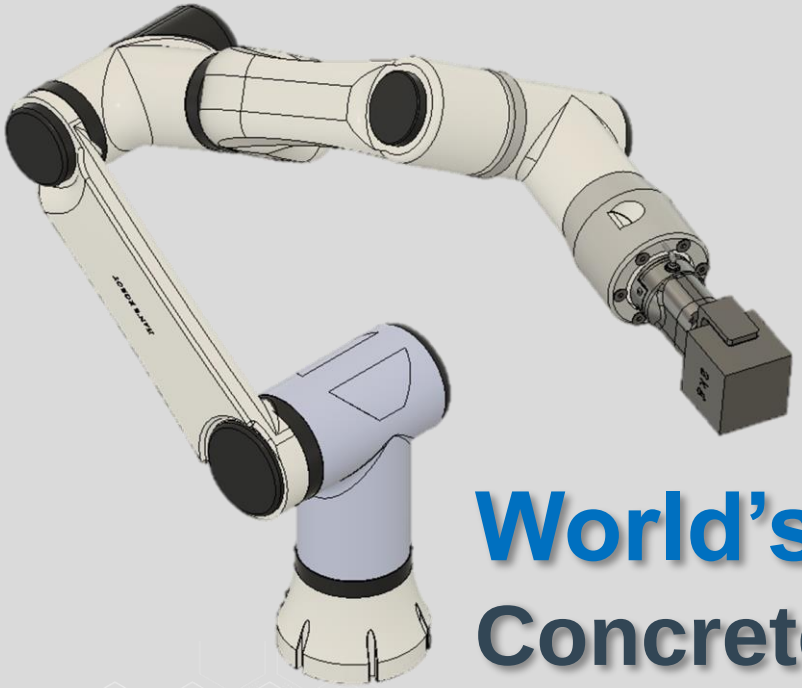
2022

Completed the development of Automated Proctor Compaction Test System

2023

New Automated Testing Systems are being explored

Smart PWL



World's First Fully Automated Concrete Cube Testing System

From Concrete Curing to Compression Testing

Conventional Concrete Cube Test Procedures

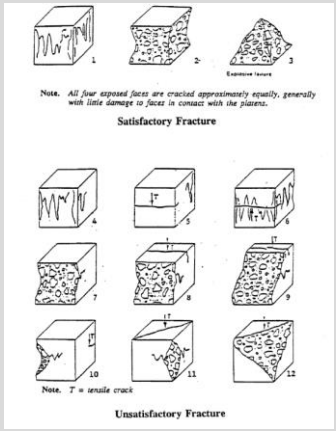
Dimension measurement by caliper

Mass measurement

Manually placing test samples into curing tank

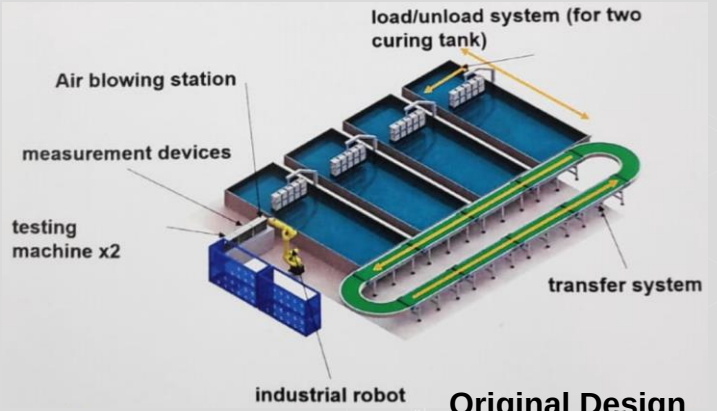
Carrying out compression test within the required testing time frame

Identification of fracture pattern

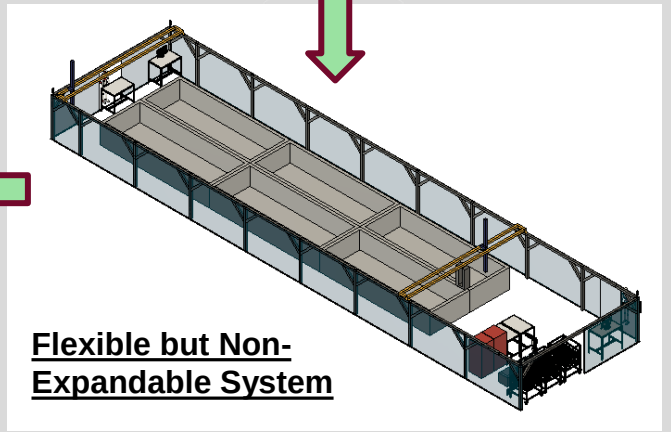


Evolution of Design of Concrete Cube Testing System

- Original scheme
  - Rigid: One hoist per curing tank
  - Non-expandable: Robotic arm with limited working envelope
  - Non-resilient: Curing tank cannot be accessed if hoist failed. Whole system halt down if transfer system failed.
- New, Improved Version
  - Flexible: All tanks share XYZ-Robots
  - Expandable: Robot arm on rail (variable length)
  - Resilient: Two hoists covering all curing tanks and two separate testing centres

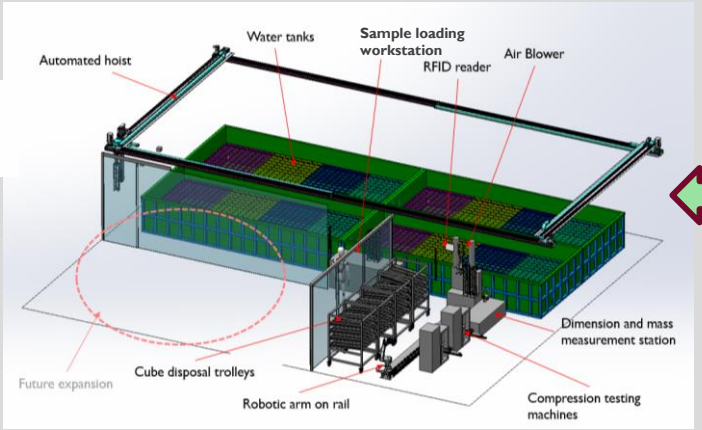


Original Design



Flexible but Non-Expandable System

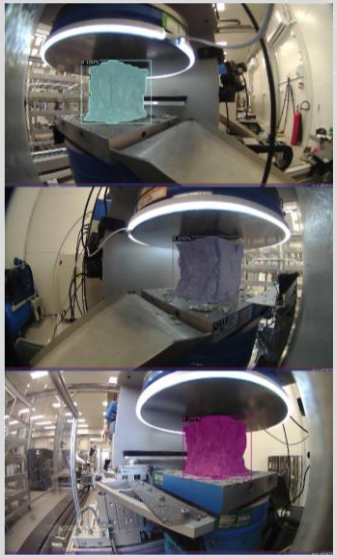
Flexible and Expandable System



Introductory Video of the Automated Concrete Cube Testing System

Technological Advancement

- The World’s First System automating the entire concrete cube testing process
- Radio Frequency Identification, Custom-made telescopic hoist, 6-axis robotic arm with movement accurate to 0.05mm
- Newly developed computer vision algorithm to identify the fracture mode of a tested concrete cube by the Artificial Intelligence System



Publicity

- Wide media coverage

Media Briefing

Filming of TVB Programme, *Innovation GPS* 創科導航

Publicity

- Overwhelming responses from industry practitioners and academia

Opening Ceremony

Visit by HKU undergraduates and industrial practitioners

Publicity

- Strong interest from the public instilled

InnoCarnival 2022

Open Day

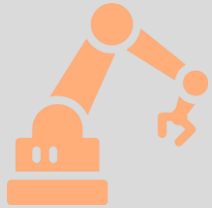
Awards

- Certificate of Merit of the HKIE Grand Award 2023 – Industrial Category
- 48th International Exhibition of Inventions Geneva 2023 – Bronze Medal

Benefits of the System

Positive Impact on the Material Testing Industry

- Successful application of innovative and advanced technologies
- Showcase and stimulates the modernisation of construction materials testing industry



Robotics

Artificial Intelligence

E xciting

A dvanced

D ull

irty

S ustainable

angerous

I ntelligent

Laboratory Testing Knowledge

Internet of Things


THE
END