THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

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

Soil Mechanics Laboratory

ZB220, Block Z,

Department of Civil and Environmental Engineering,

The Hong Kong Polytechnic University

Opening Minds • Shaping the Future
啟迪思維 • 成就未來

Introduction

The Soil Mechanics Laboratory consists of four rooms with approximate area of 250cm^2. Both conventional and advanced testing apparatus are installed in the laboratory. The Laboratory provides facilities and technical support for soil testing related to testing, research and special consulting project.

It houses advanced equipment including:

> Stress-path Controlled Saturated and Unsaturated Triaxial System

> Double-cell Triaxial Apparatus with Small Strain Measurement

> Novel Multi-purpose Apparatus for Unsaturated Soils

> Temperature, Suction and Stress-Controlled Direct Shear Apparatus

> Triaxial Apparatus for multi-phase flow analysis

> Triaxial Apparatus with Bender Elements

> Large-size Direct Shear box

> Dynamic Hollow Cylinder Apparatus

> PolyU-patented Truly Triaxial Apparatus

> FRP-reinforced seawater sea-sand concrete piles under static and cyclic loadings

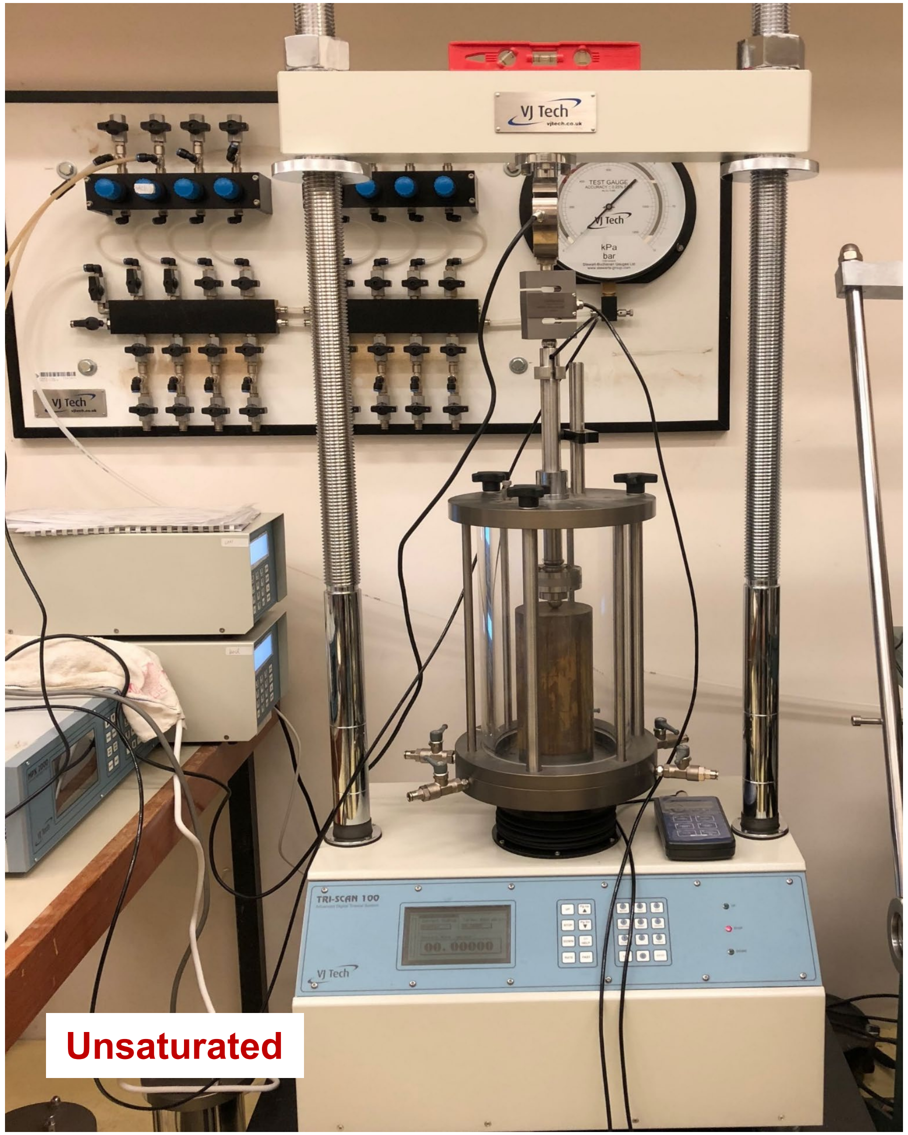
> Physical Model Test of Geotextile-Reinforced Sand Fill over HKMD Improved by DCM Columns

> Coupled CFD-DEM Simulation for Column Collapse Test

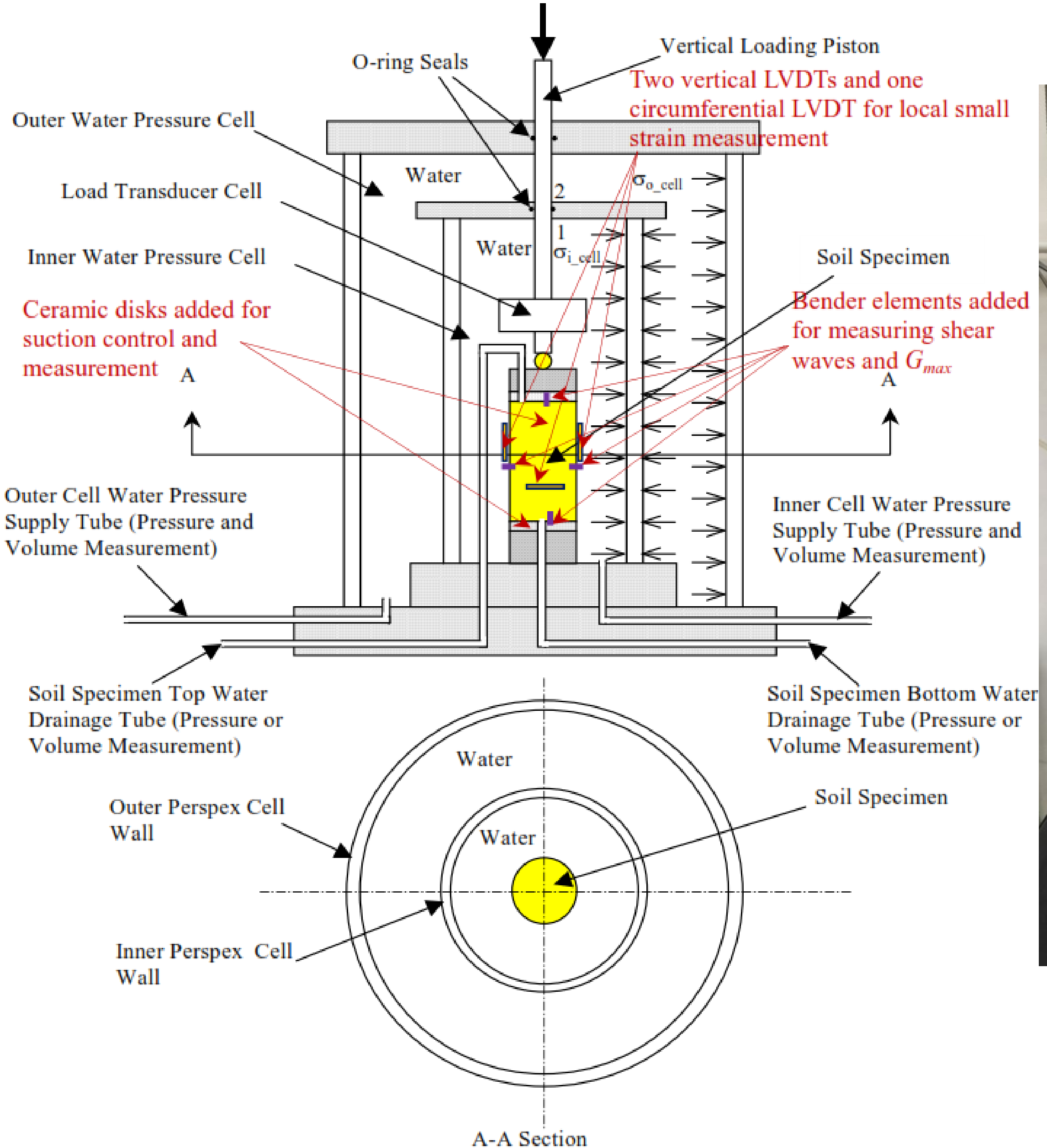
> Large physical model tests: reclamation project

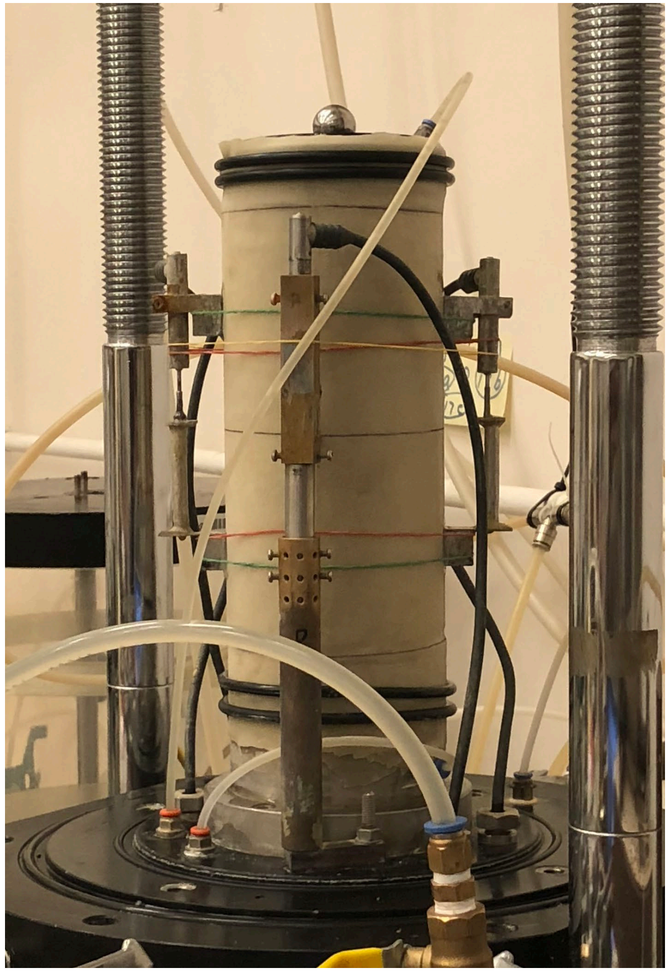
Laboratory Testing for Research

➢ **Stress-path Controlled Saturated and Unsaturated Triaxial System**

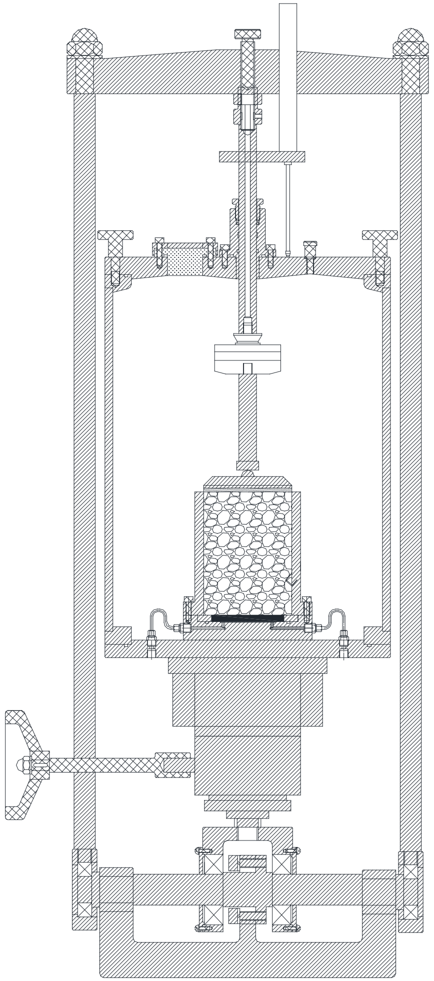


➢ Double-cell Triaxial Apparatus with Small Strain Measurement

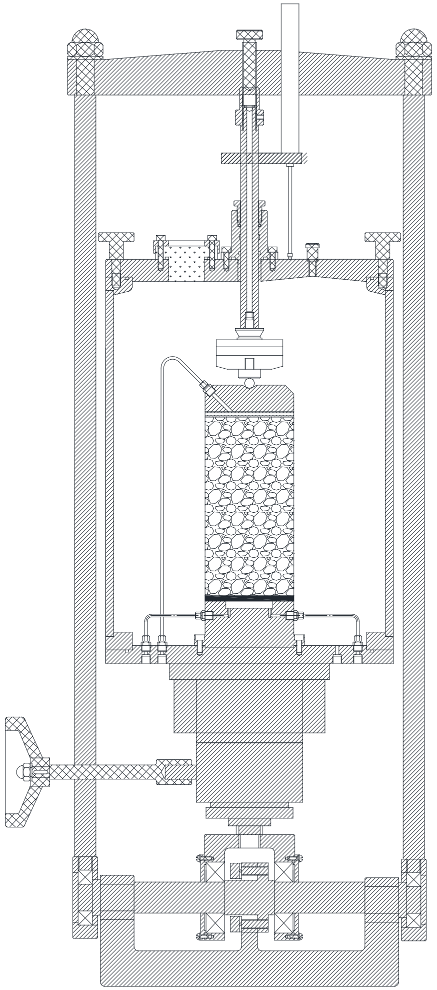




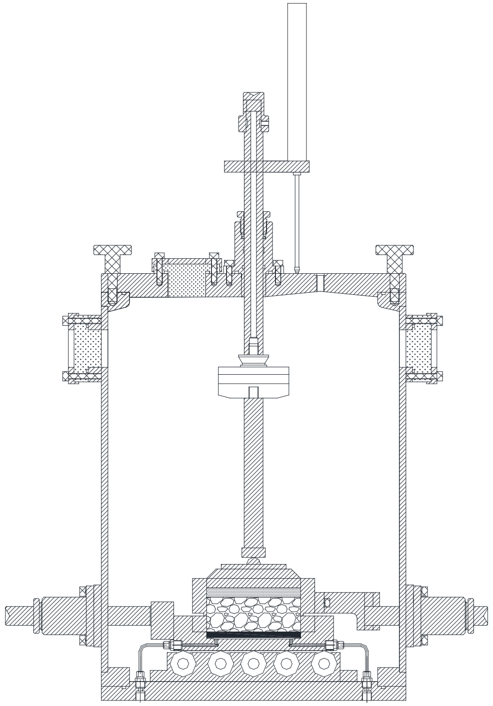
➢ Novel Multi-purpose Apparatus for Unsaturated Soils



Modified Pressure Plate Module and Modified Oedometer Module

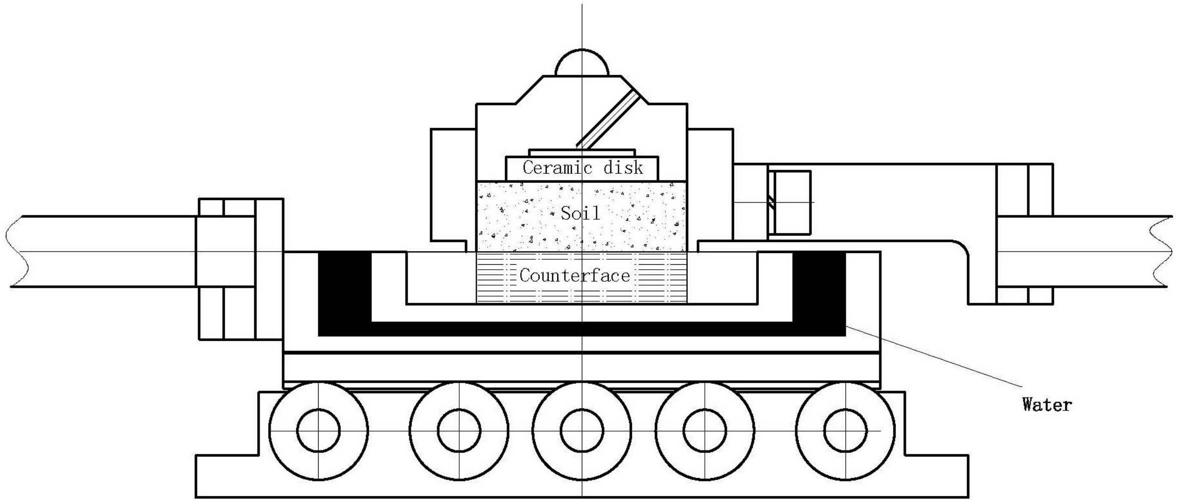


Modified Direct Shear Module



Modified Triaxial Creep Module

➢ Temperature, Suction and Stress-Controlled Direct Shear Apparatus

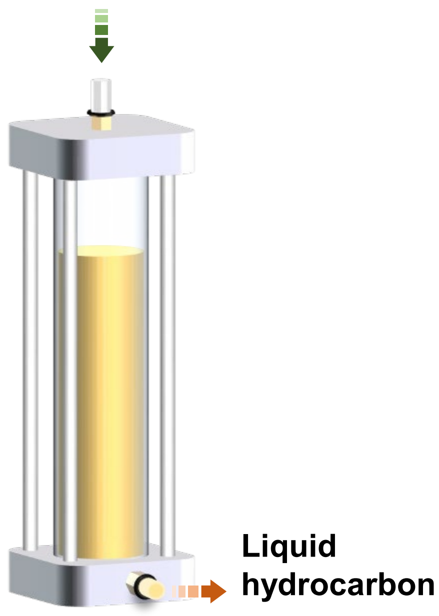


Capable of controlling 4 independent variables for studying behaviour of unsaturated and saturated soil-structure interfaces

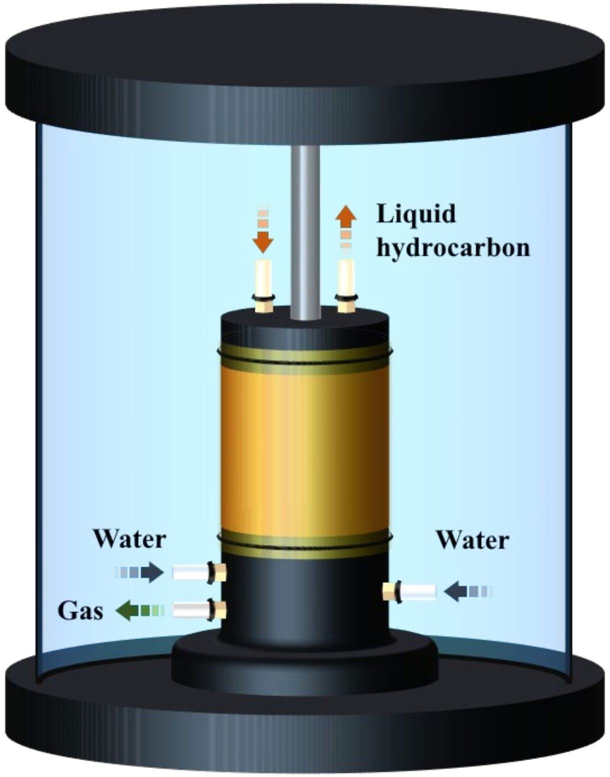
(a) Temperature; (c) Shear displacement;

(b) Shear stress; (d) Suction

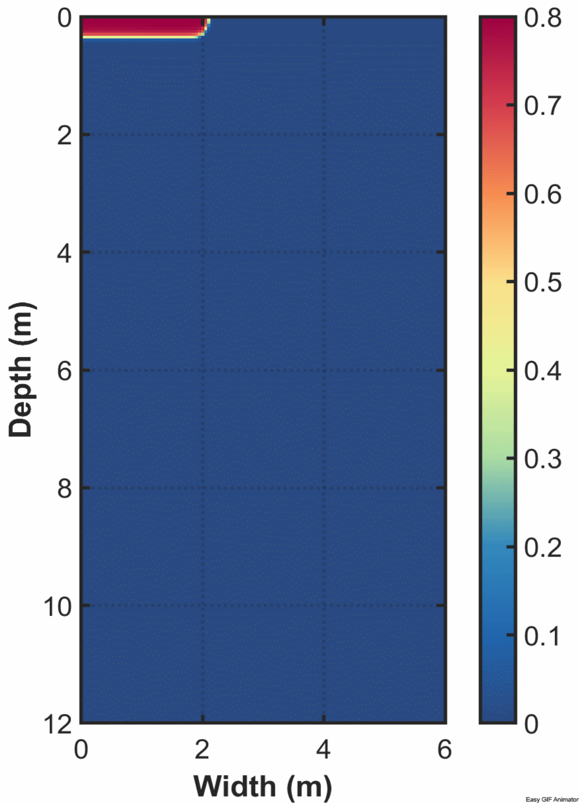
➢ Triaxial Apparatus for multi-phase flow analysis



Oil cylinder



Triaxial cell with CDG sample

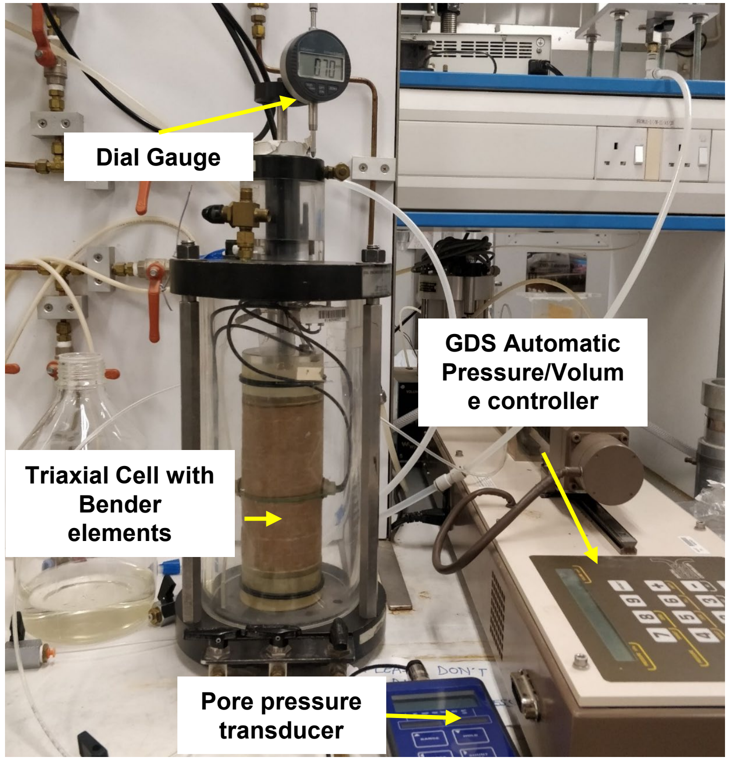


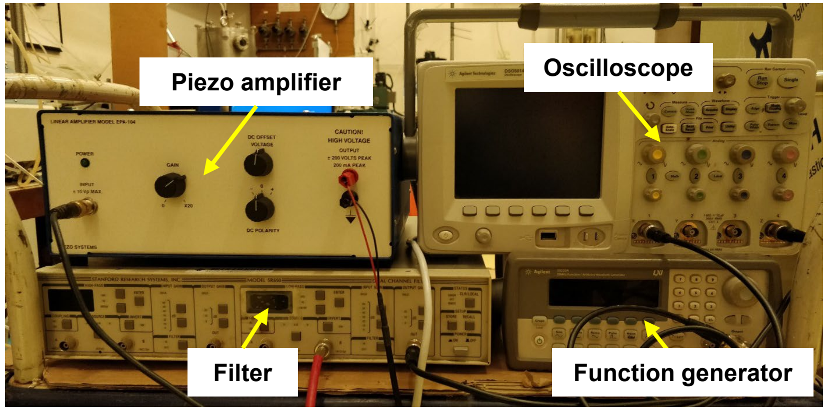
Numerical simulation

For measuring the pressure and saturation change of three phases (water, gas and liquid hydrocarbon) in the unsaturated soil under varying load

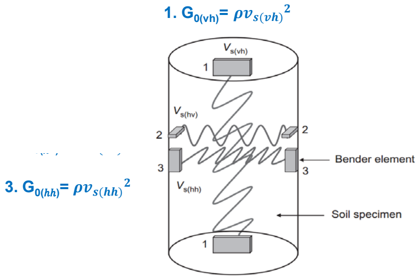
- **Studying hydro-mechanical behaviour in the contaminated soil**

➢ Triaxial Apparatus with Bender Elements





Electronic peripherals for shear wave propagation

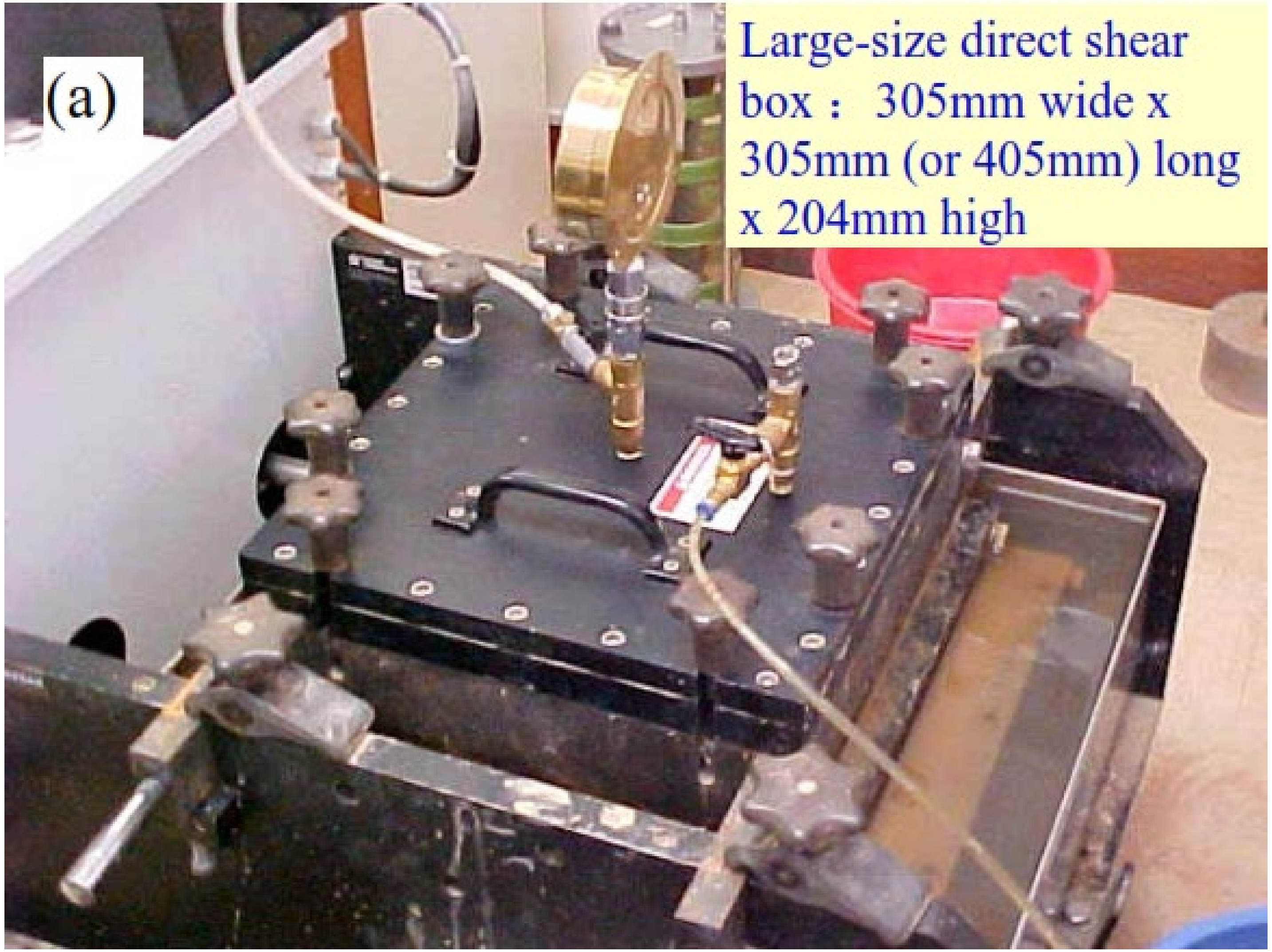


Stiffness Anisotropy:
$G_{0(hh)}/G_{0(hv)}$ or $G_{0(hh)}/G_{0(vh)}$

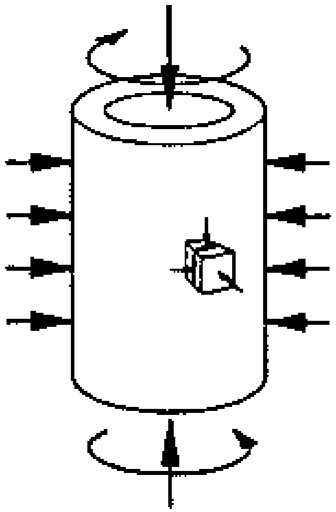
For measuring very small strain shear modulus (G_0 or G_{max}) in three (3) directions by measuring the shear wave velocity using bender elements

- **Studying influence of stress state variables on stiffness anisotropy**

Large-size Direct Shear box



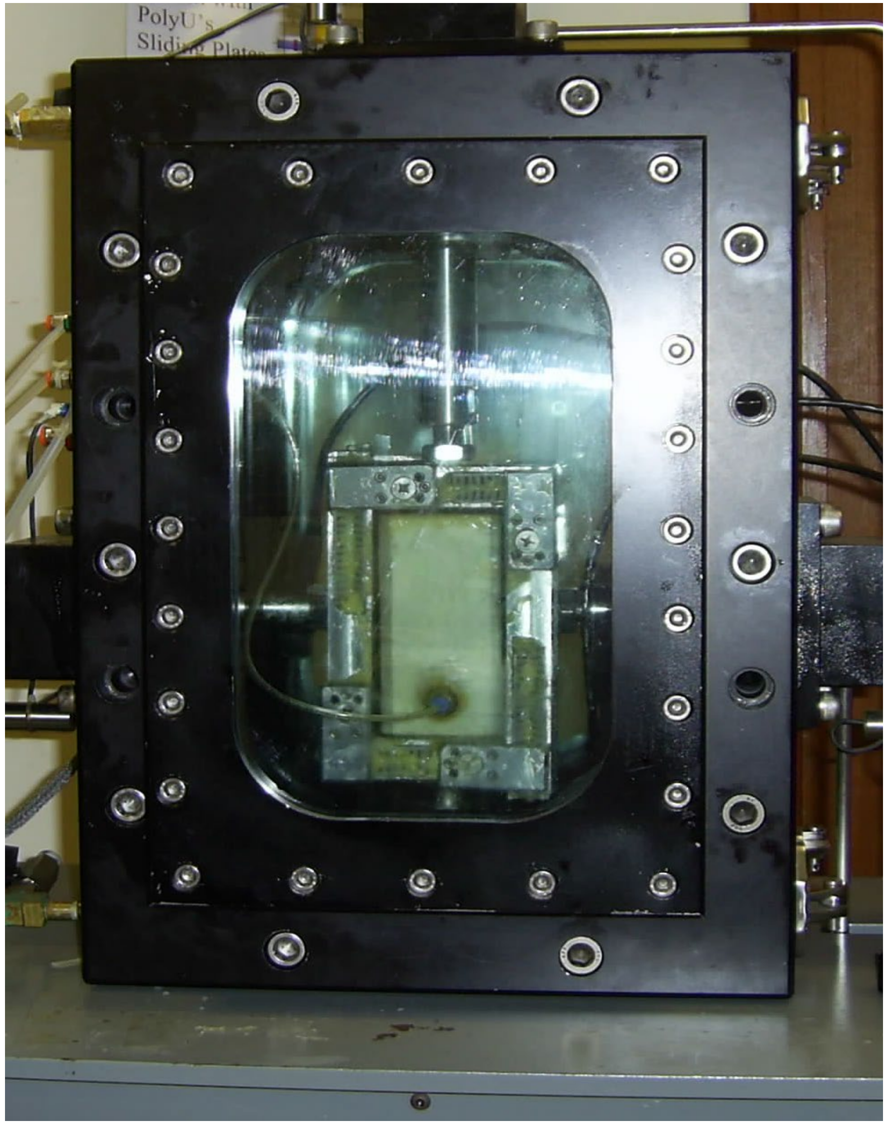
➢ Dynamic Hollow Cylinder Apparatus

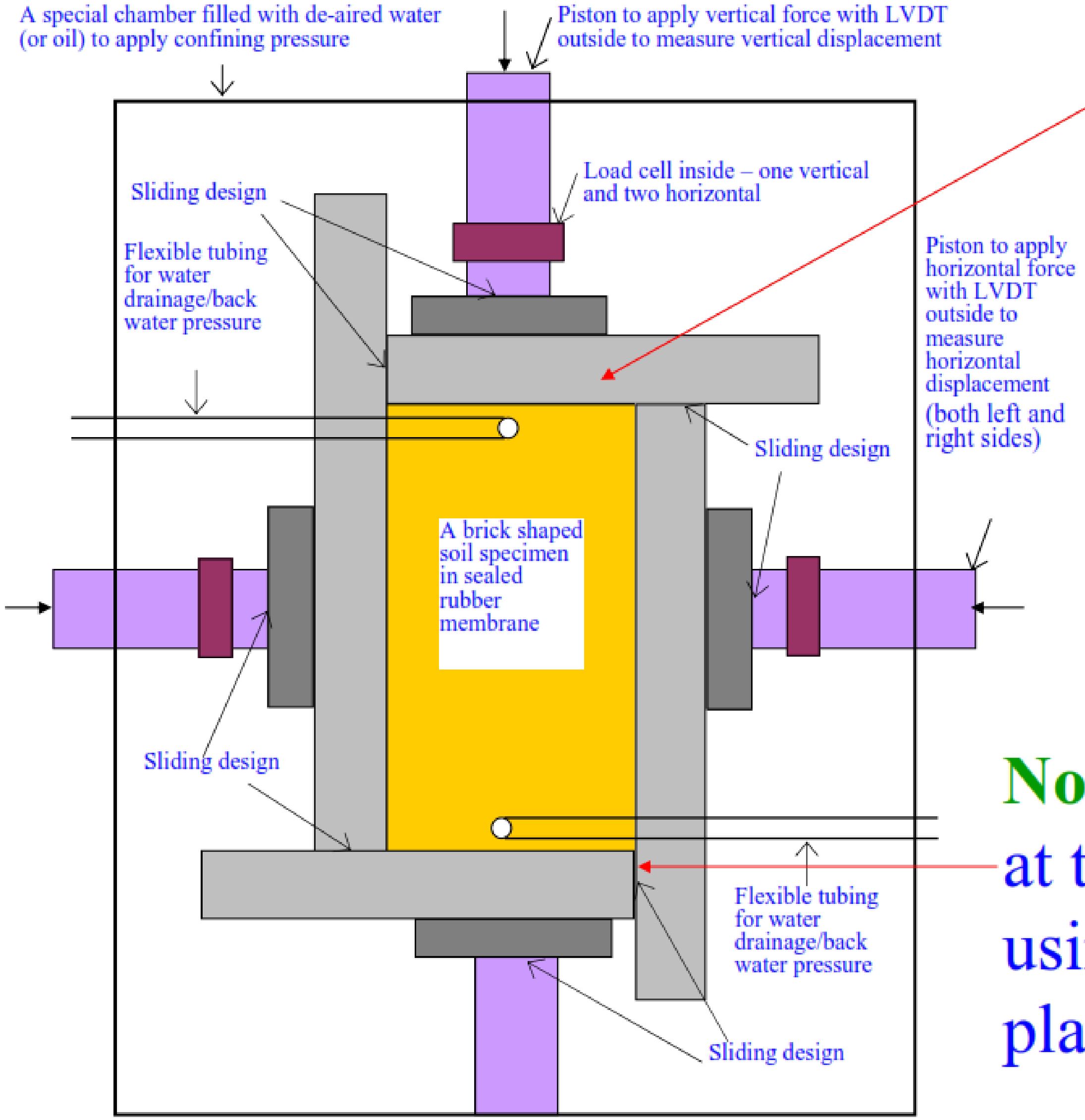


Capable of controlling 4 independent loadings for studying behaviour of a hollow soil specimen under

(a) pure shearing;
(b) plane strain;
(c) rotation of the principal stress;
(d) influence of the middle principal stress

➤ PolyU-patented Truly Triaxial Apparatus





New sliding loading plates and setup

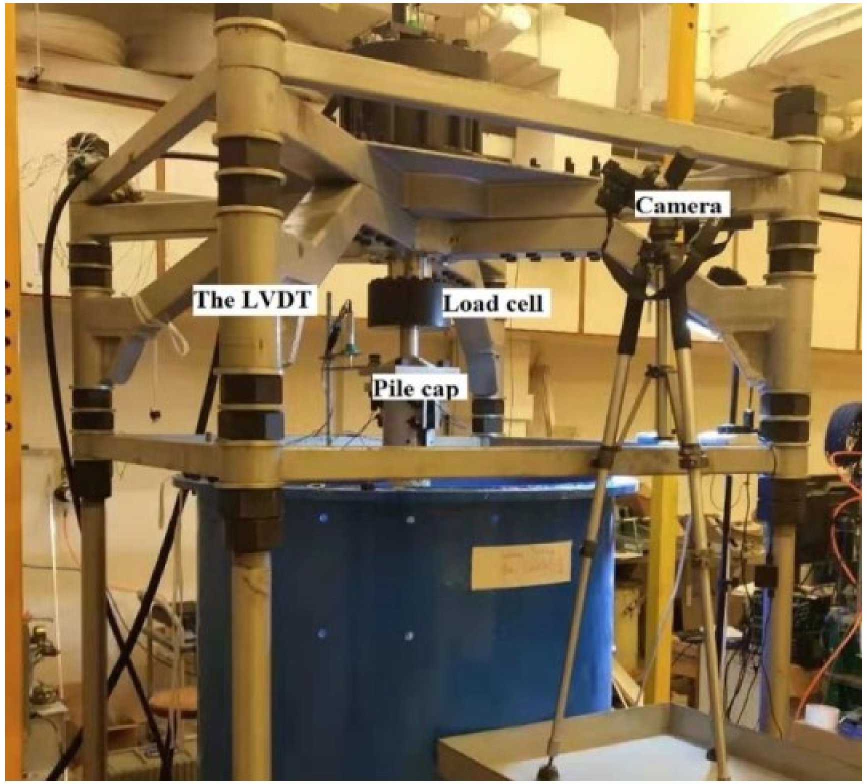
创新的设计

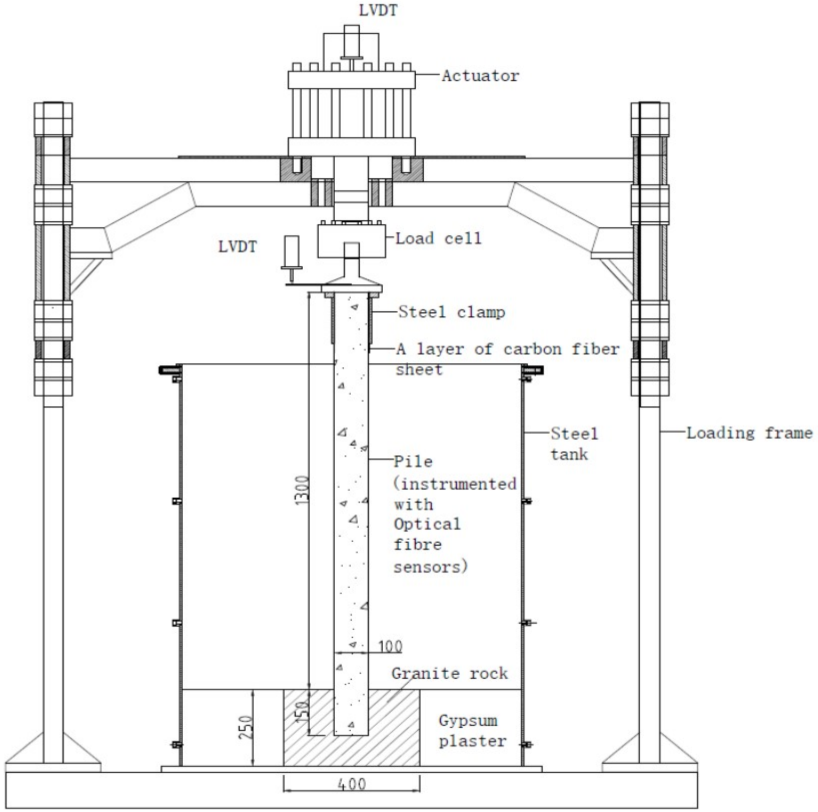
No Interference at the corners using sliding plates

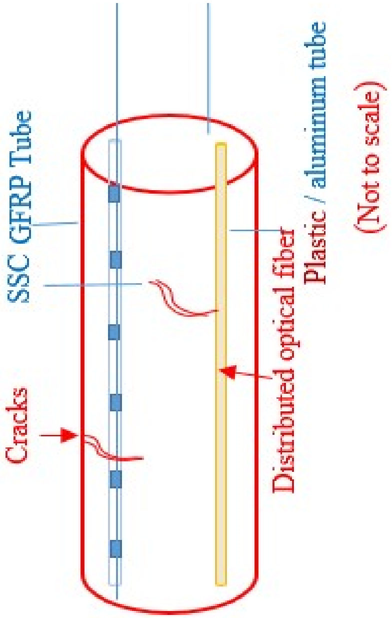
Introduction of Representative Physical Modelling Experiments

FRP-reinforced seawater sea-sand concrete piles under static and cyclic loadings

- In the proposed project, a physical model of SSC-FRP pile was set up with a steel tank of about 1000mm in diameter and a loading frame (American GCTS dynamic triaxial test-rig), at the bottom of which a granite rock socket was surrounded and fixed by gypsum plaster.
- The model contains a SSC-FRP pile in diameter of 100mm and 150mm-depth rock socket.



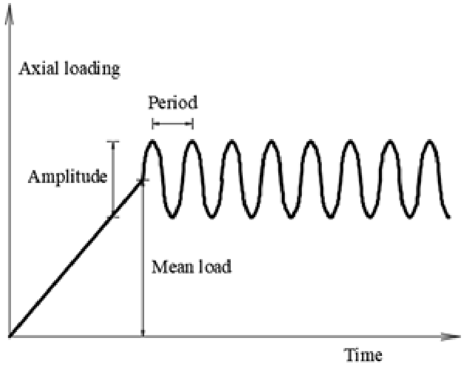




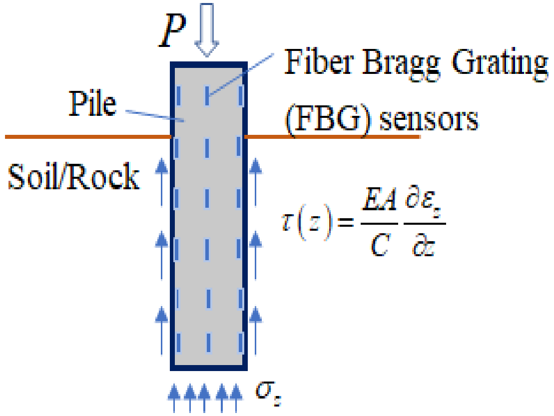
Physical model pile

FRP-reinforced seawater sea-sand concrete piles under static and cyclic loadings

- To simulate the loading caused by superstructure and marine environment, the model will be subjected to cyclic loading of different frequencies, and then loaded to failure under monotonic static loading.
- FBG and OFDR sensing system will be combined to monitor cracks & debonding and measure the deformations.

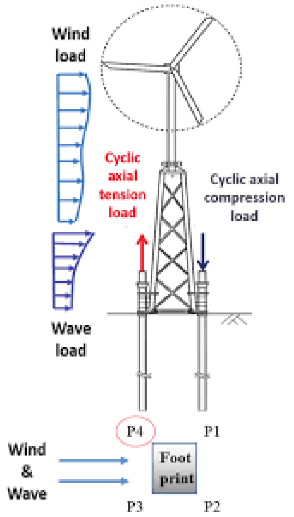


Cycling loading scheme

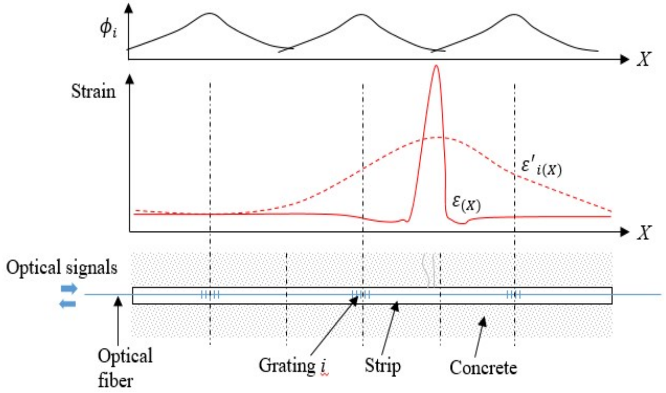


The measurement of friction and load transfer in rock socket and soils

- Shortage of fresh water & river sand
- Corrosion
- High maintenance cost



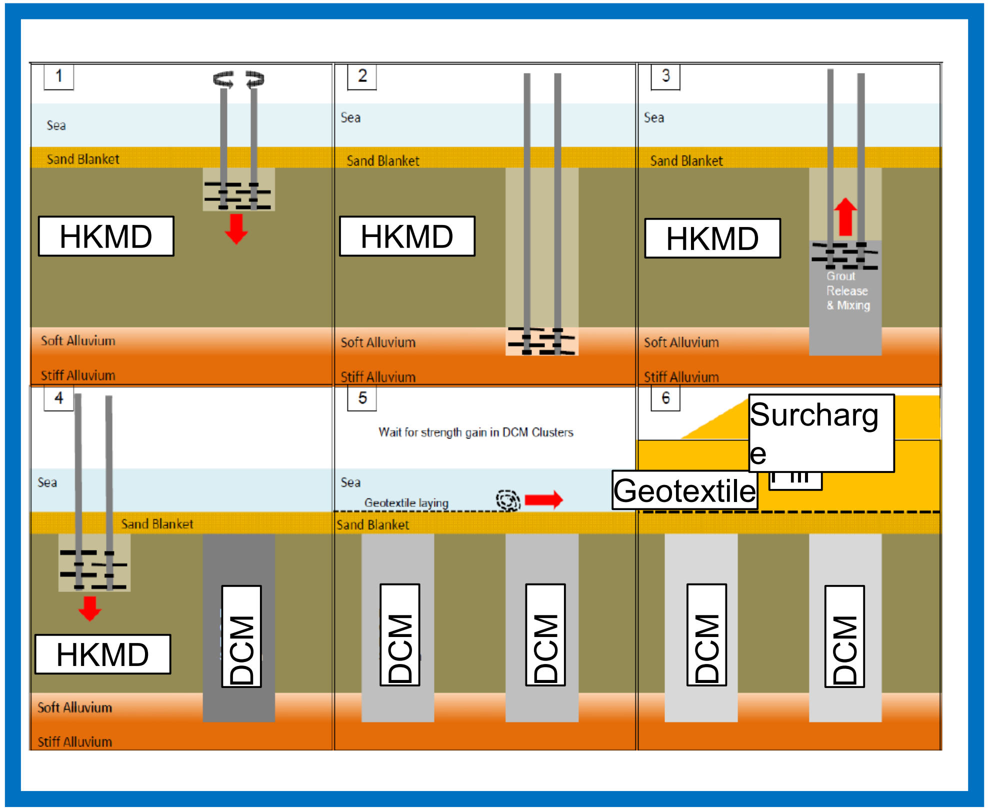
- Corrosion resistive
- High Strength
- Cost effective

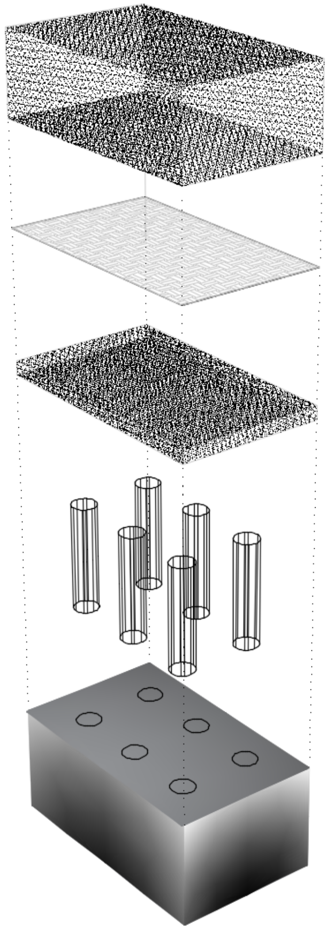


FBG and OFDR sensors

Physical Model Test of Geotextile-Reinforced Sand Fill over HKMD Improved by DCM Columns

One of proposed solutions for the 3rd Runway Reclamation Project of HKIA





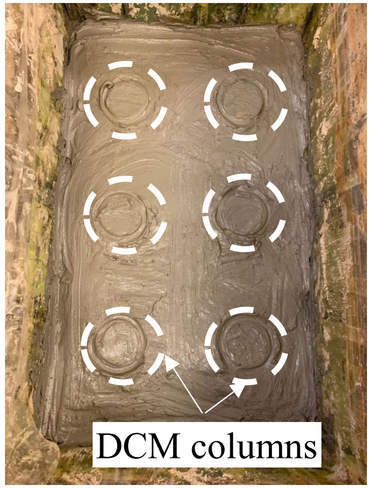
Sand

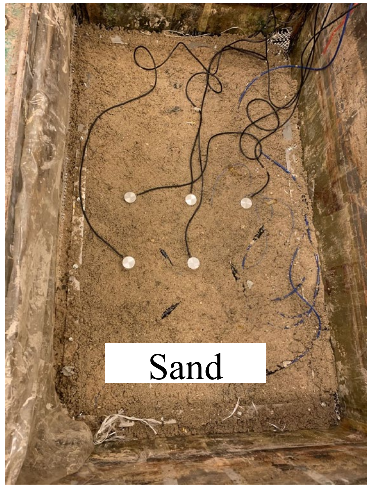
Geotextile

Sand

DCM columns

HKMD





Engineering background → Small-scale physical model test

Physical Model Test of Geotextile-Reinforced Sand Fill over HKMD Improved by DCM Columns

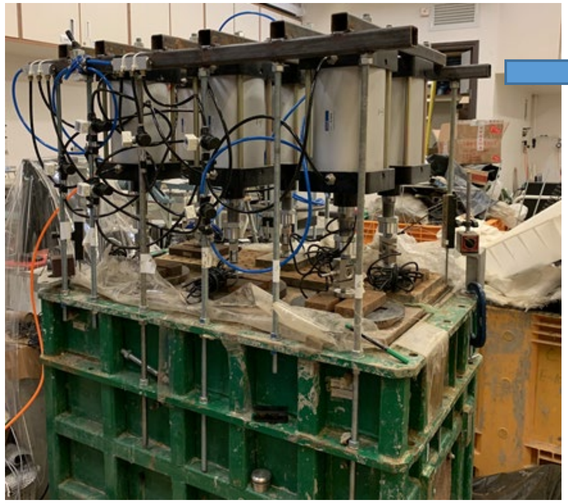
Instrumentations

NI datalogger

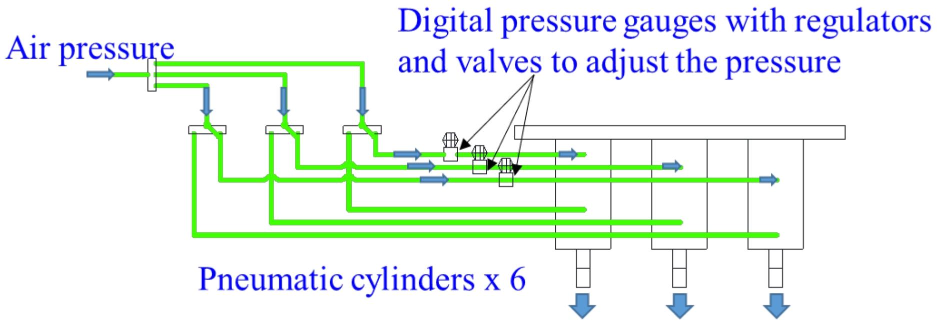
Pore pressure transducers
Earth pressure transducers
LVDTs
Load cells

MicronOptics Interrogator

FBG sensors

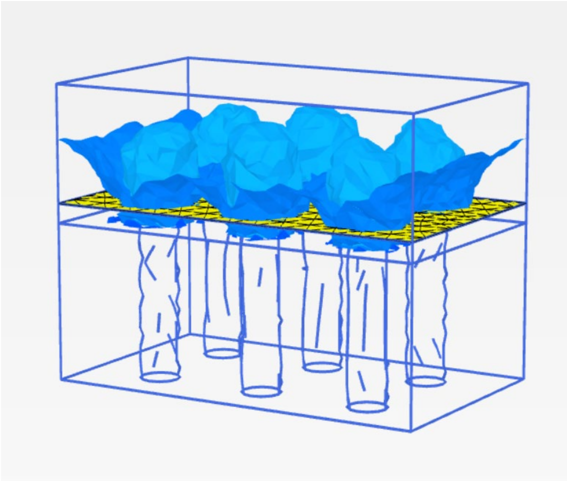


Loading system

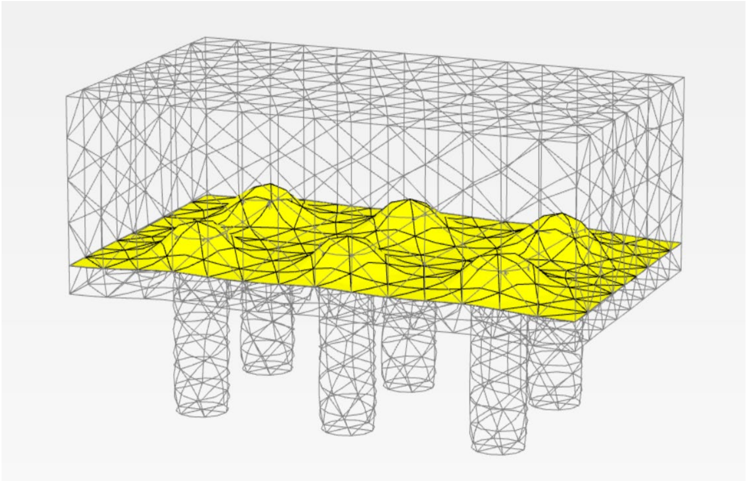


Research focuses

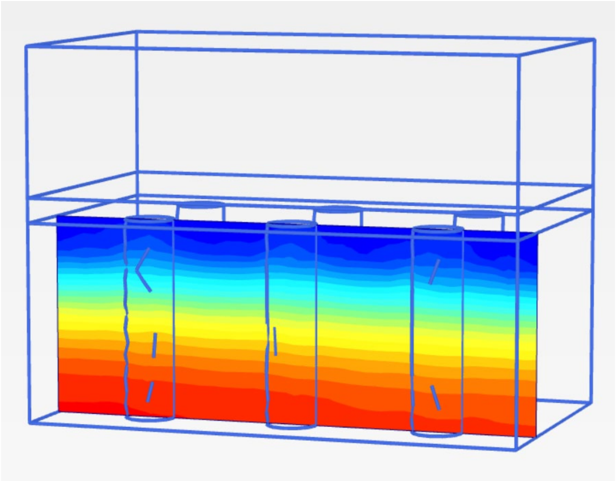
Soil arching



Effect of geotextile reinforcement



Soft soil consolidation



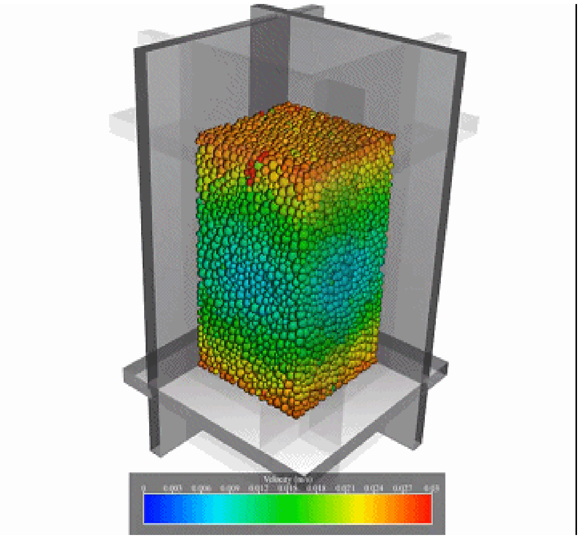
Coupled CFD-DEM Simulation for Column Collapse Test

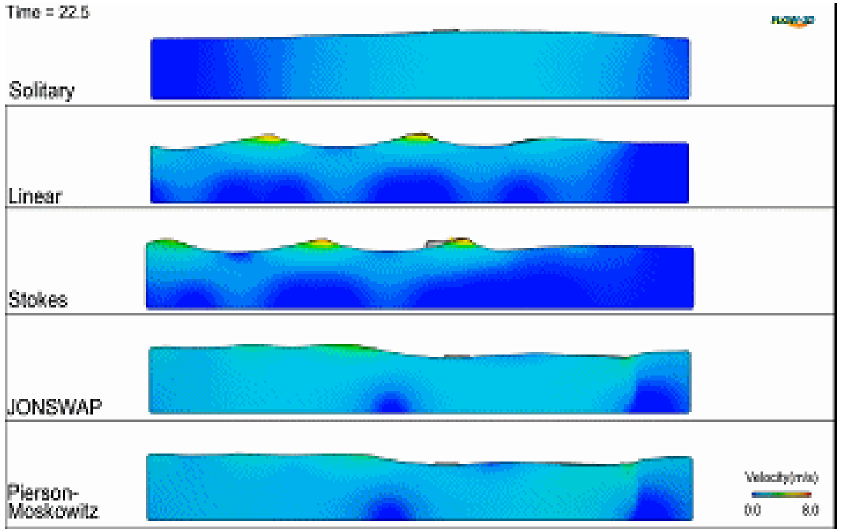
Discrete Element Method (DEM)

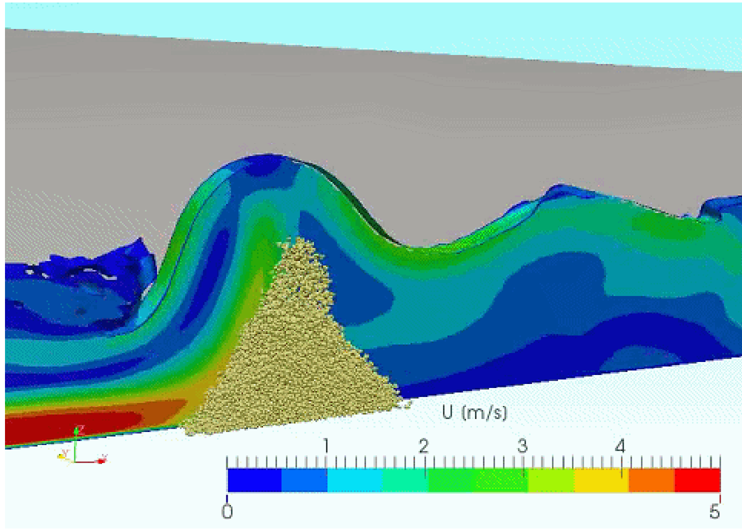
Numerical technique for computing the motion and effect of particle materials

Coupled CFD-DEM Simulation

Coupled technique for solving problems with fluid & particle interaction







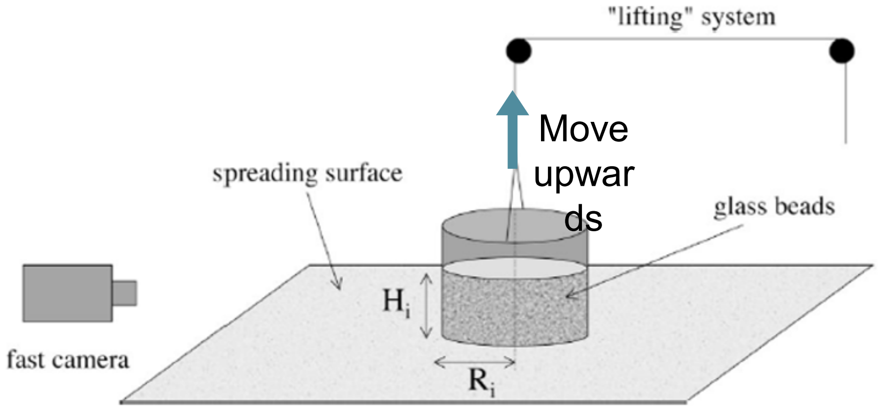
Computational Fluid Dynamics (CFD)

Technique using numerical analysis and data structures for analyzing fluid flows

Coupled CFD-DEM Simulation for Column Collapse Test

Column Collapse Test

Conventional test for investigating particle flow and interaction



Quarter column

In water

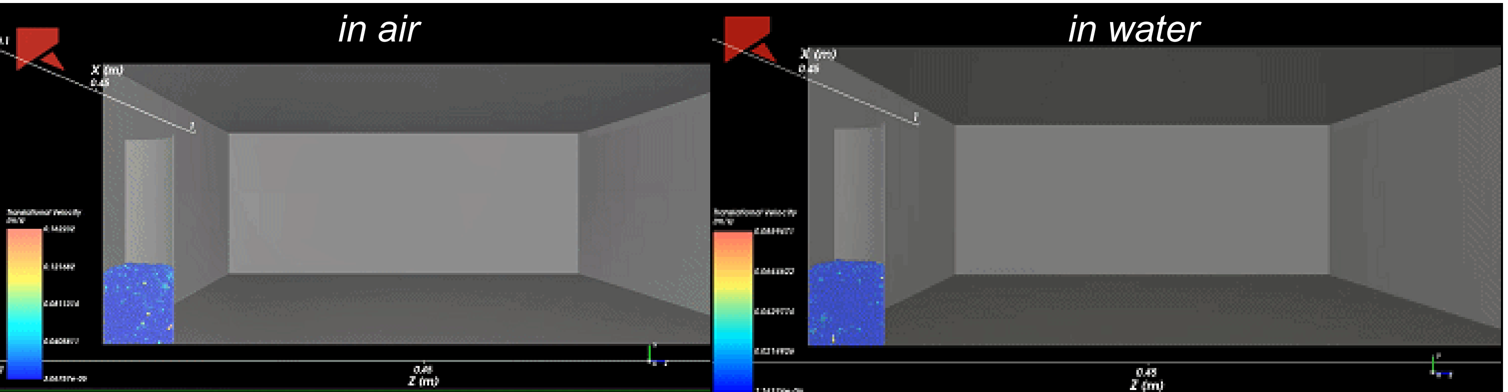
Physical Model

Try column collapse test in water and record the successive profiles by fast camera.

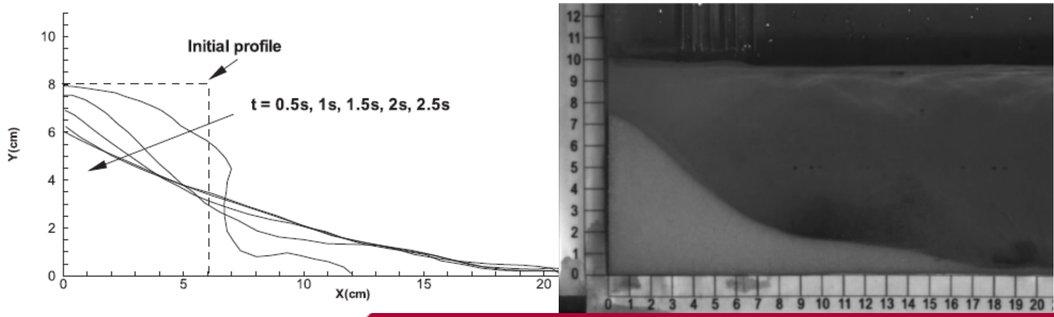
Comparison

Validation

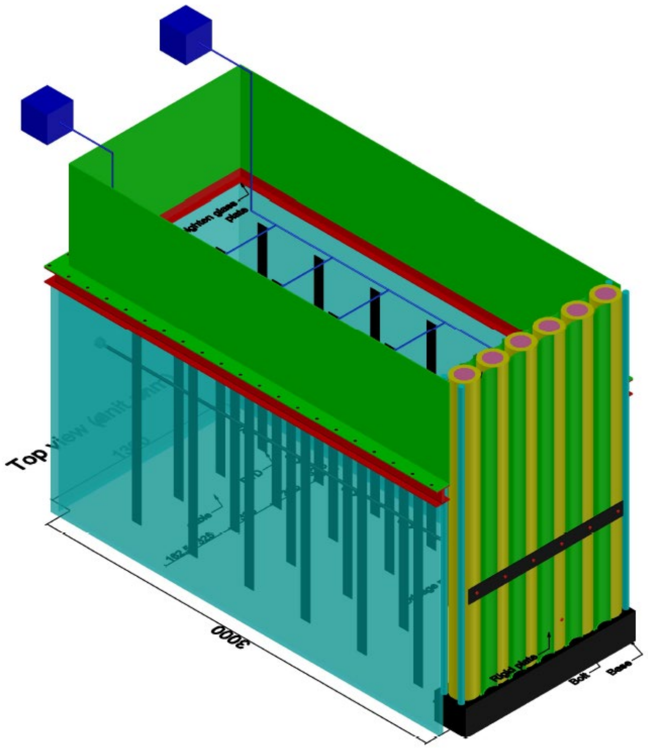
Coupled CFD-DEM Simulation By Rocky DEM & ANSYS Fluent

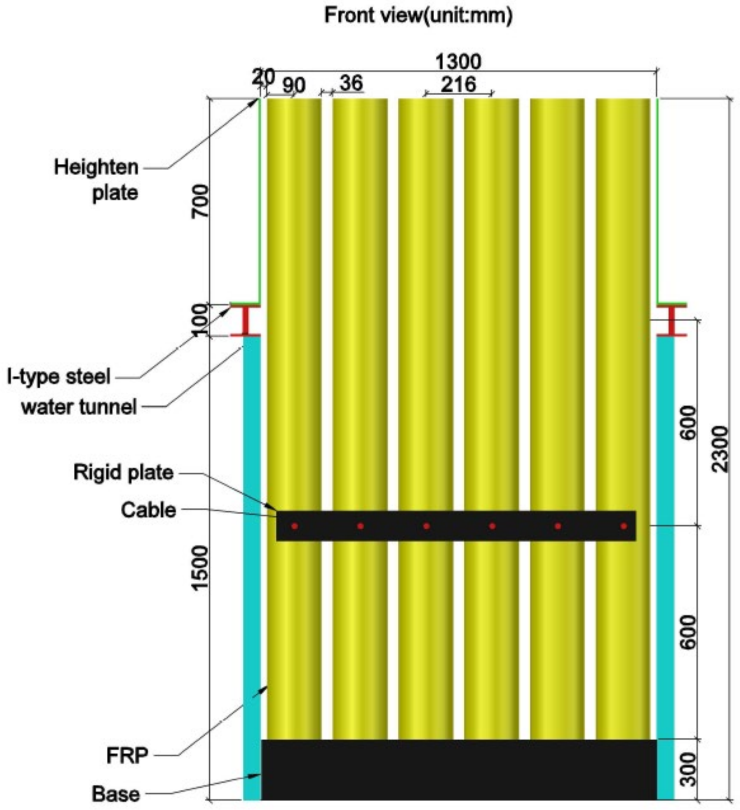


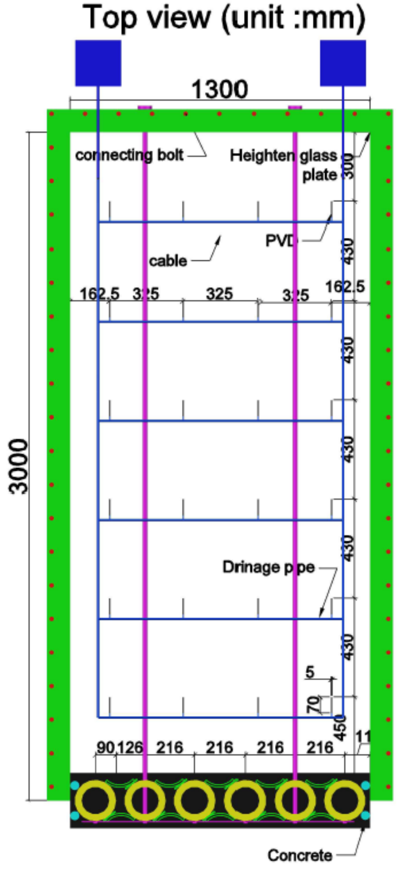
Test results analyzed by PIV (particle image velocimetry)



Large physical model tests: reclamation project

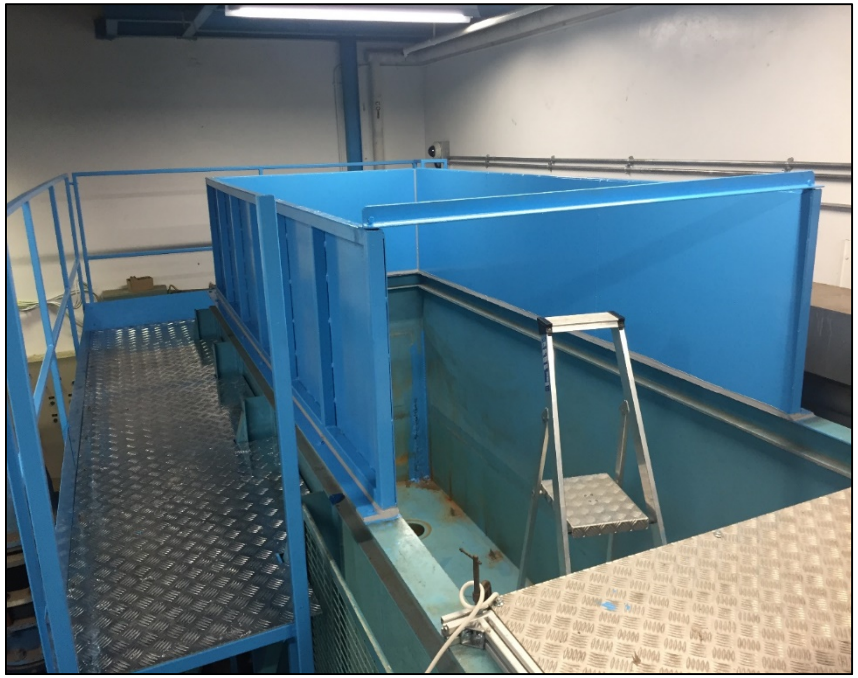






Background: To study self-weight consolidation, and fast consolidation of HKMD by vertical or horizontal drains with vacuum preloading inside an impermeable pile wall.

Large physical model tests: reclamation project

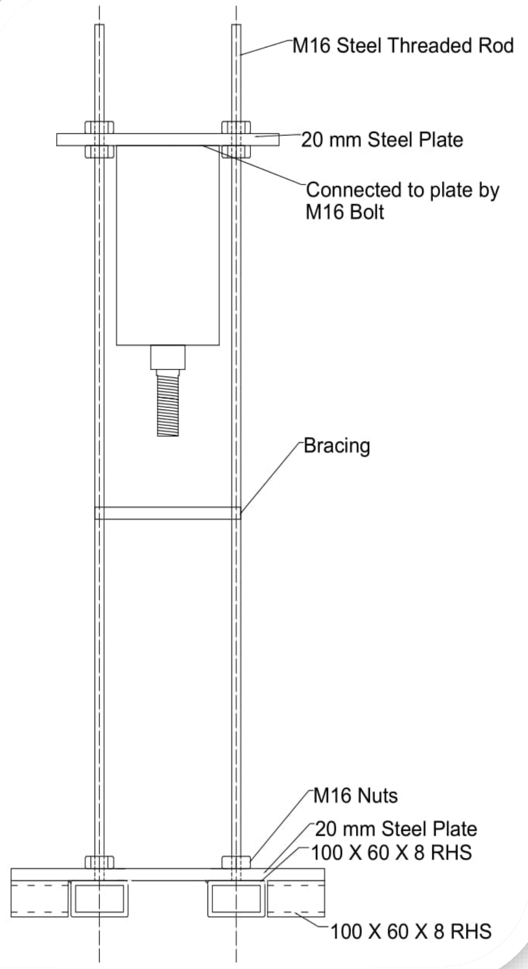


Heighten steel plate and working platform

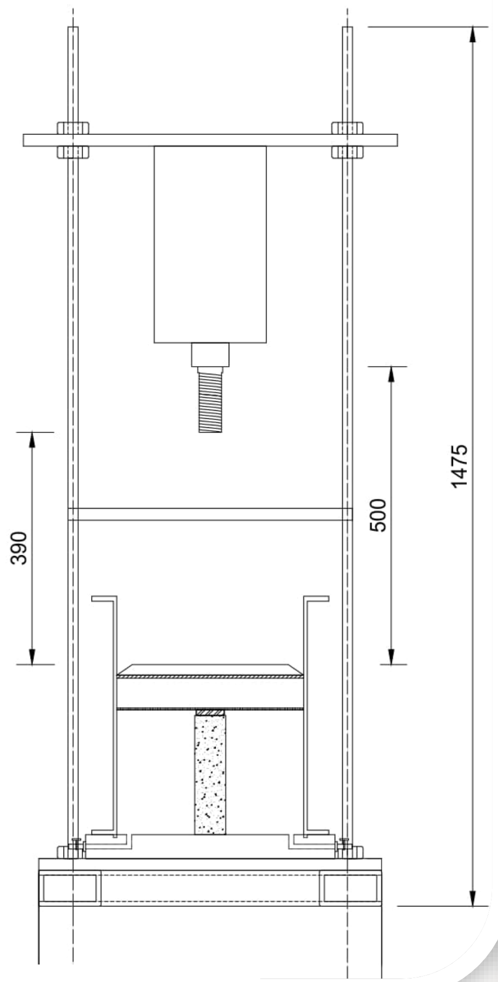
FRP base with bars melded

FRP Installation

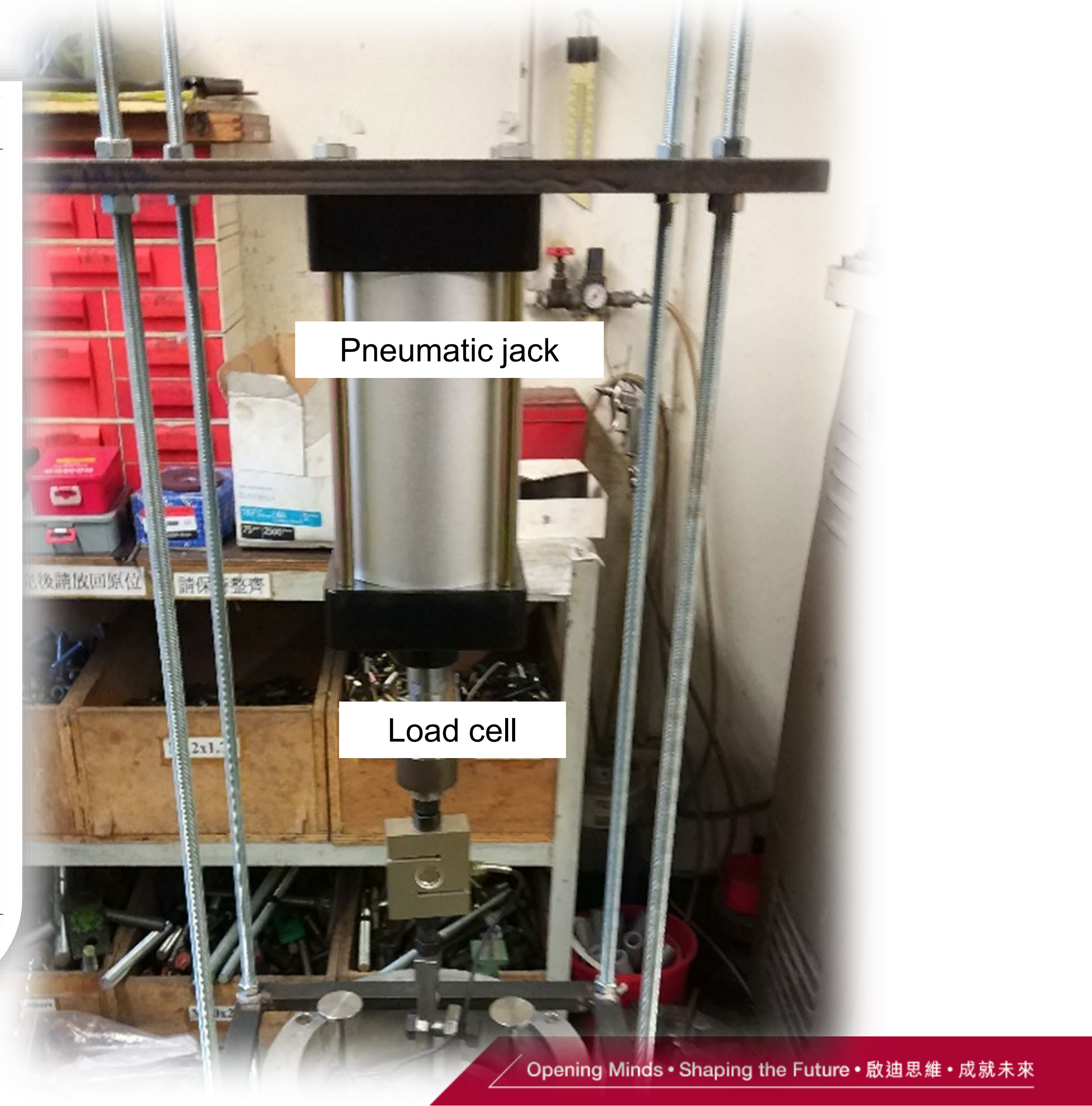
Evaluating the environmental impact of contaminated sediment column stabilized by deep cement mixing



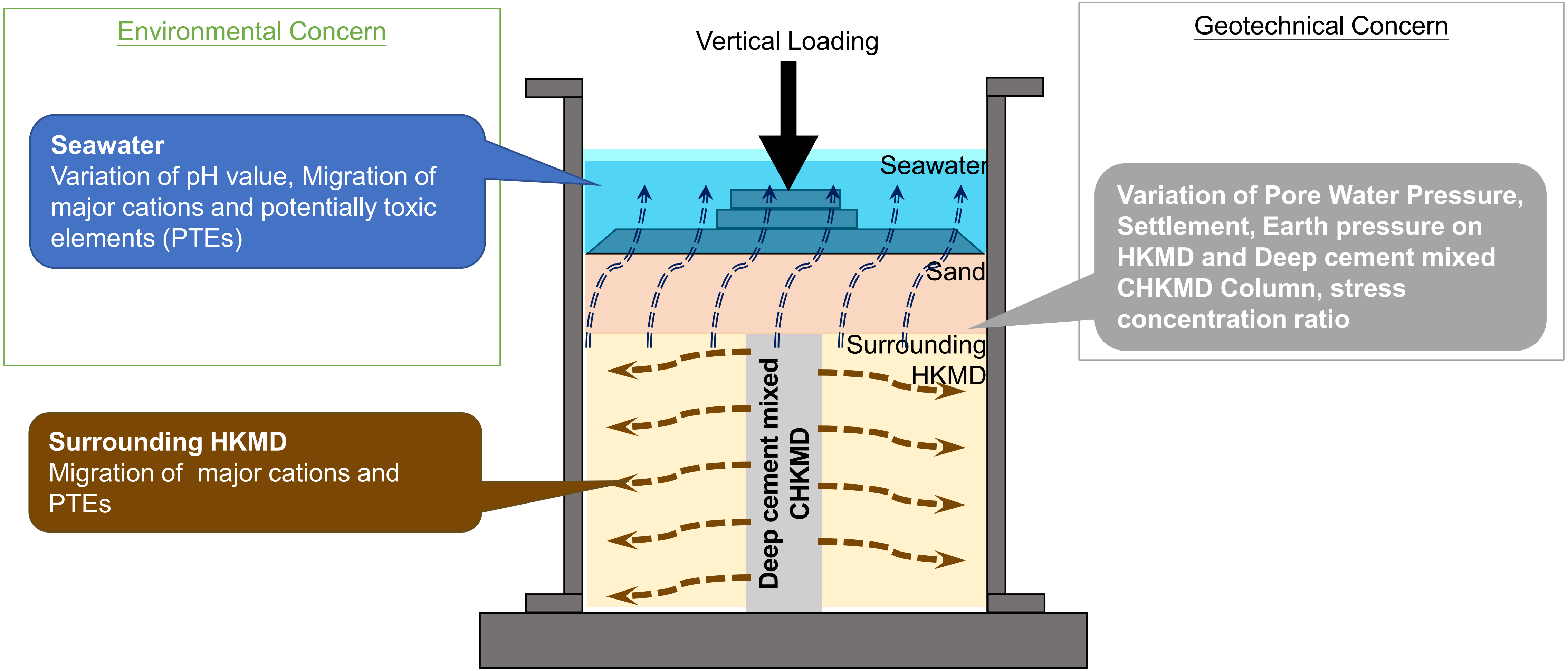
Side View



Front View

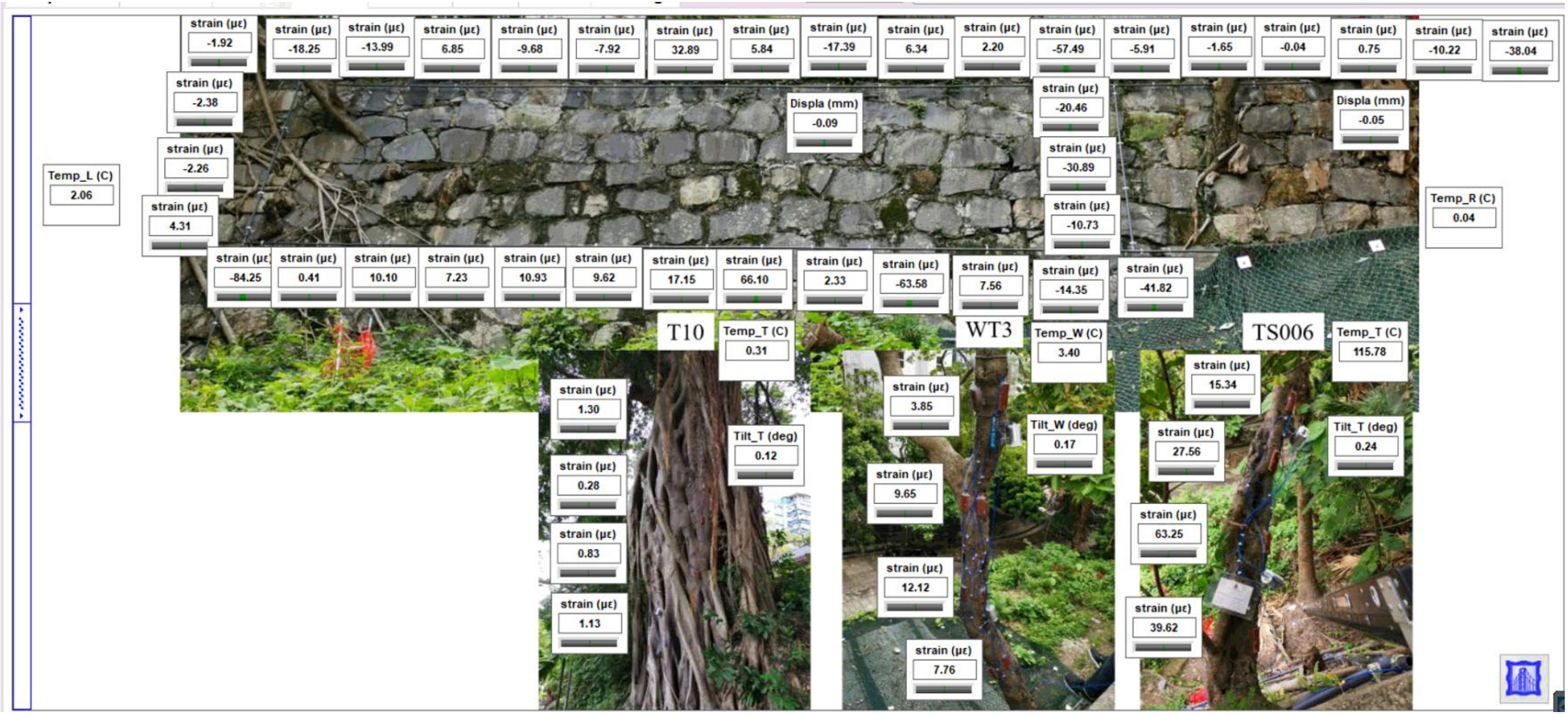


Evaluating the environmental impact of contaminated sediment column stabilized by deep cement mixing



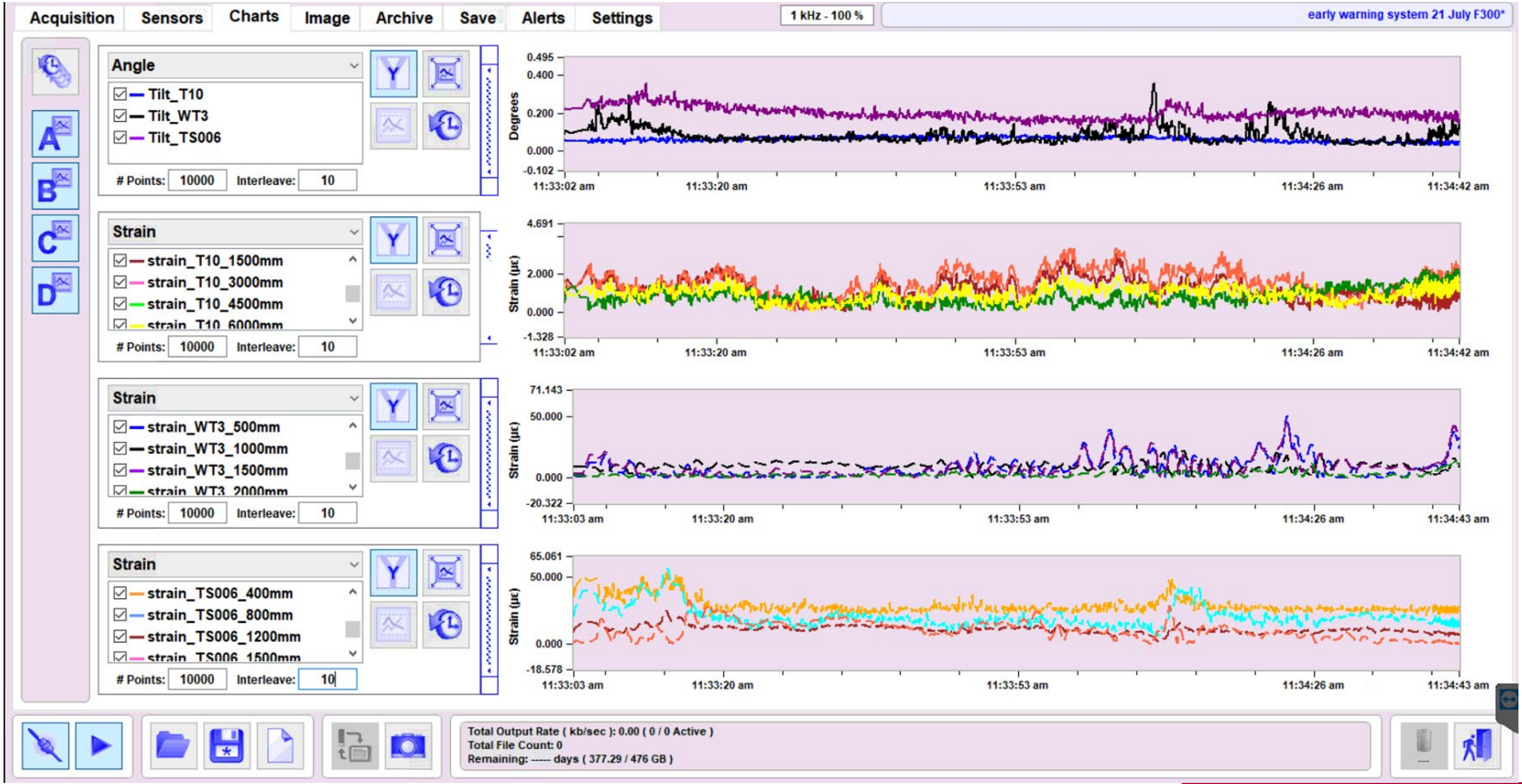
Automatic early warning system of retaining wall and trees

Real-time status of monitored wall and trees



Automatic early warning system of retaining wall and trees

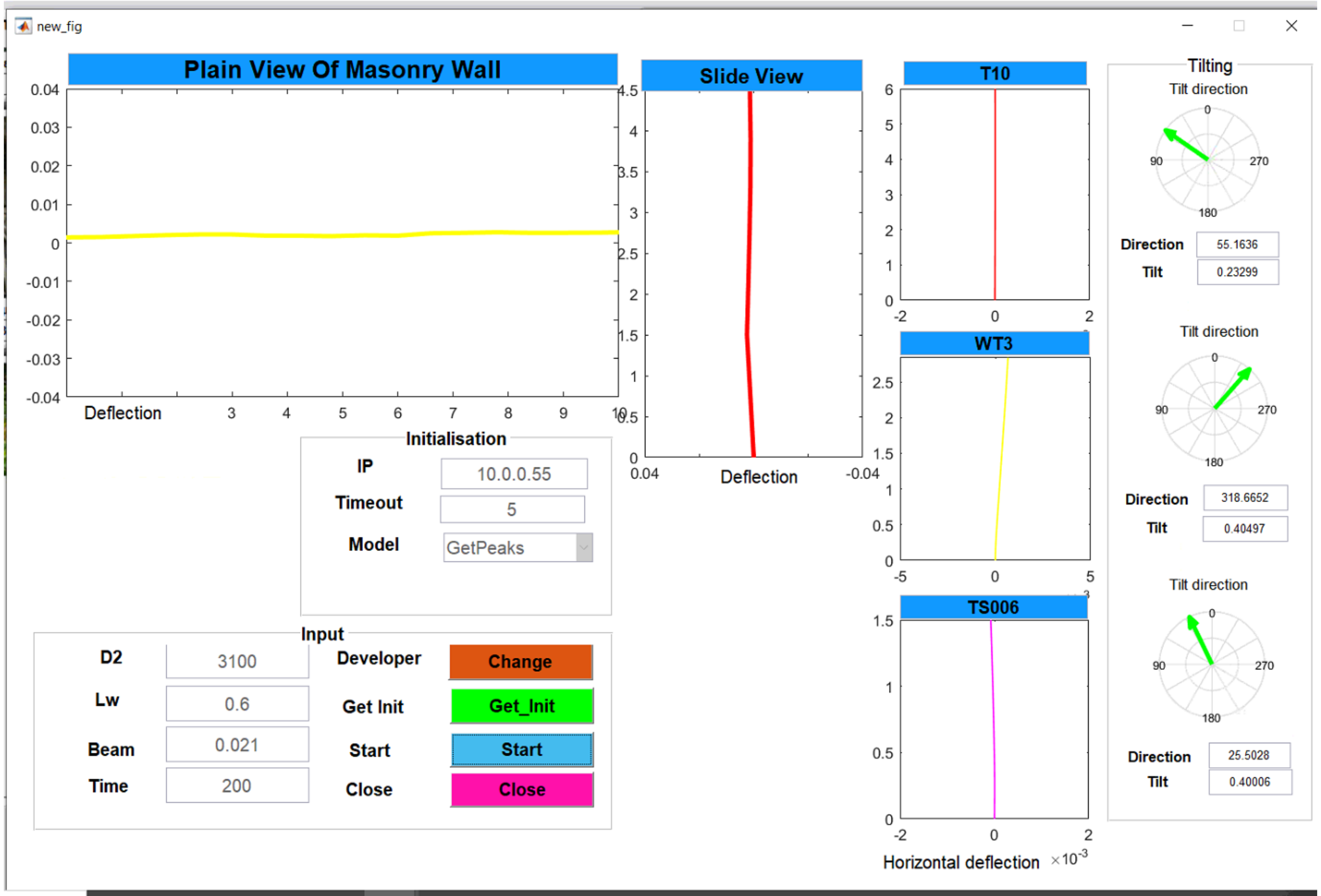
History of dynamic behaviour of monitored wall and trees



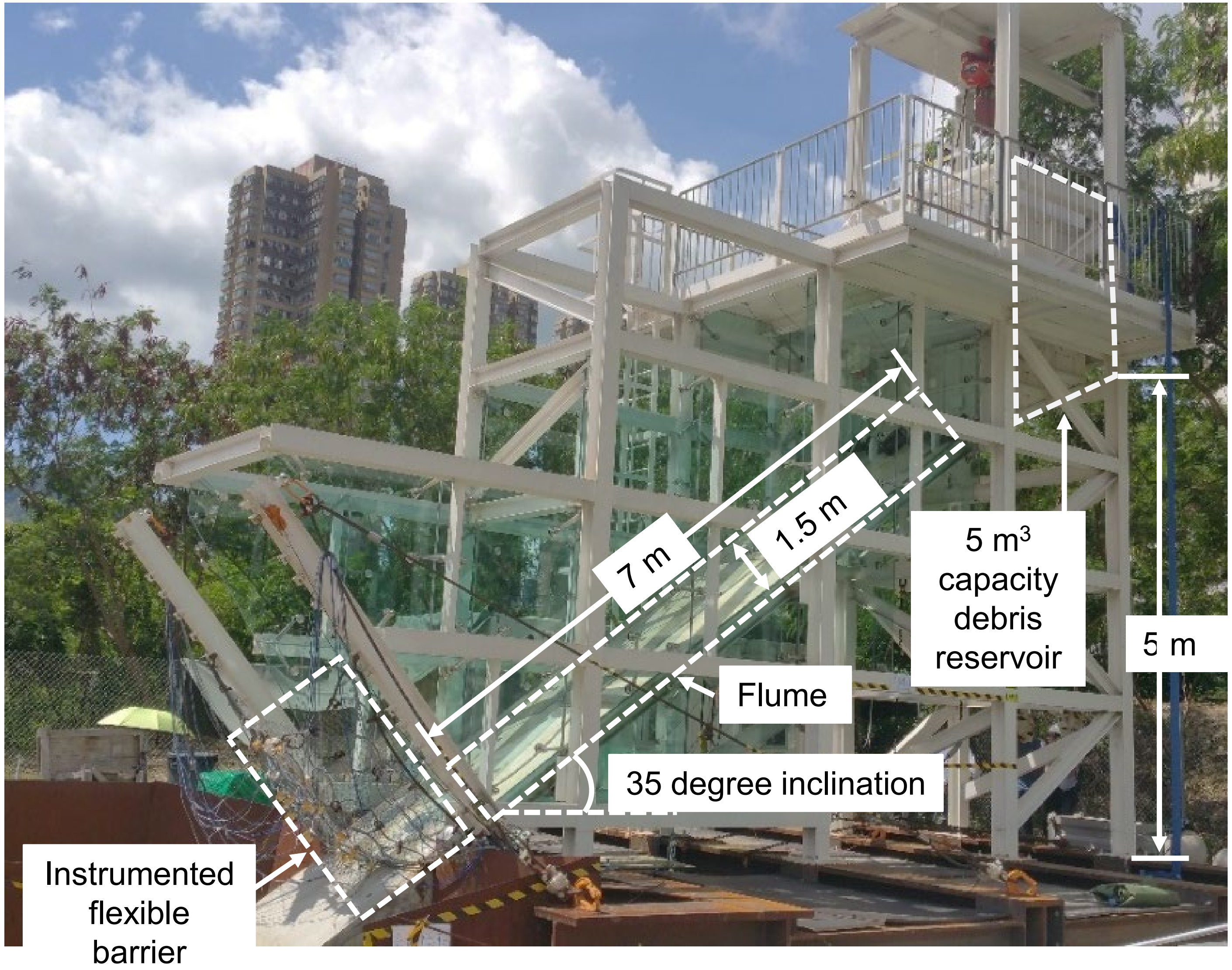
Researchers: TAN Dao-Yuan, WU Pei-Chen, CHEN Wen-Bo, LIN Shao-Qun

Automatic early warning system of retaining wall and trees

Visualization of deformation of monitored wall, deflection and tilt of monitored trees



Large-scale physical modelling experiments for debris flow impact



Large-scale physical modelling experiments for debris flow impact

Flexible barrier was empty before Test 1

Flexible barrier was partially blocked by the debris deposition in Test 1

Flexible barrier was almost filled by the debris deposition in Test 2

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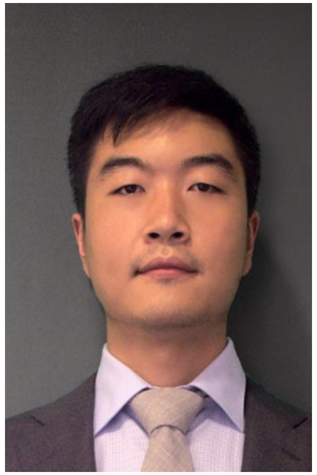

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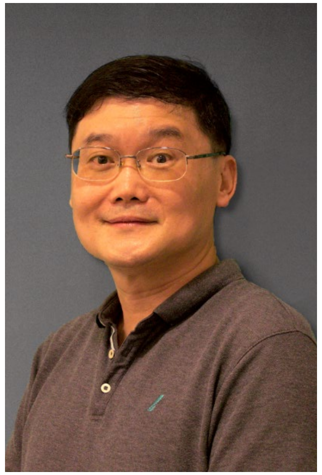

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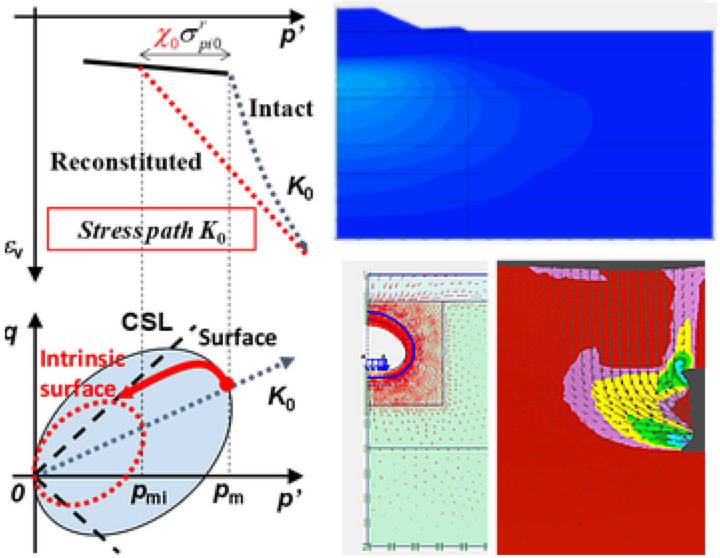
Research Spotlight

Time-dependency of Soft Soils & Engineering Application

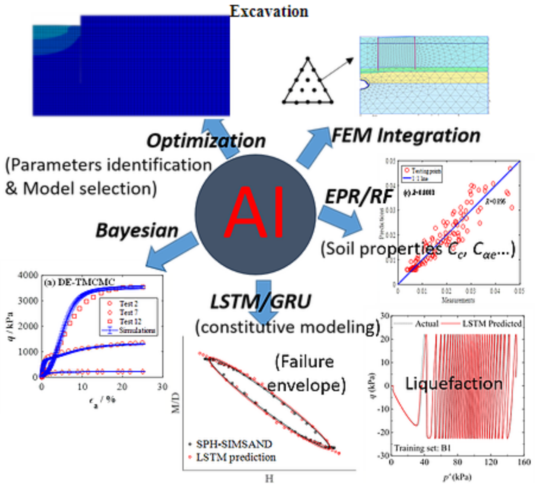
Natural soft clays exhibit several features: (a) significant anisotropy developed during their deposition, sedimentation, consolidation history and any subsequent straining; (b) some apparent bonding which will be progressively lost during straining; and (c) time-dependent stress-strain behaviour which has a significant influence on the shear strength and the pre-consolidation pressure. Since all these features cannot be neglected, we considered all the above features in the modelling. The application of the proposed model ANICREEP requires the same experimental information as needed for the Modified Cam Clay model, which makes the model attractive for geotechnical practice.



Practice of Artificial Intelligence in Geotechnics

We have extensively performed the application of AI in geotechnics due to the strong capacity of solving non-linear and high-dimensional problem of AI. Currently, we focuses on the following topics:

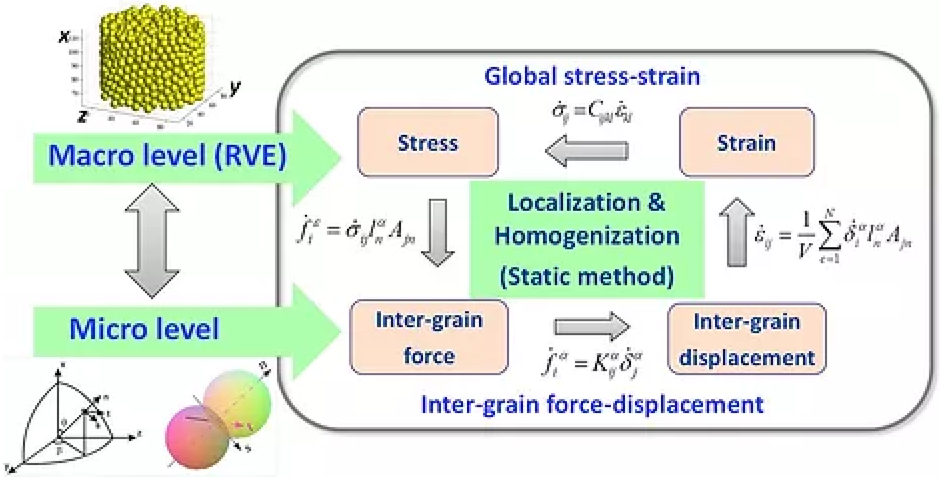
1. Optimization-based parameters identification & model selection, and development of platform;
2. Bayesian-based parameters identification & model class selection;
3. Modelling of soil properties by Evolutionary Polynomial Regression (EPR), Random Forest (RF) and other machine learning algorithms;
4. Deep learning based constitutive modelling of SSI and soils using Long Short-Term Memory (LSTM) neural network or its variants.



Research Spotlight

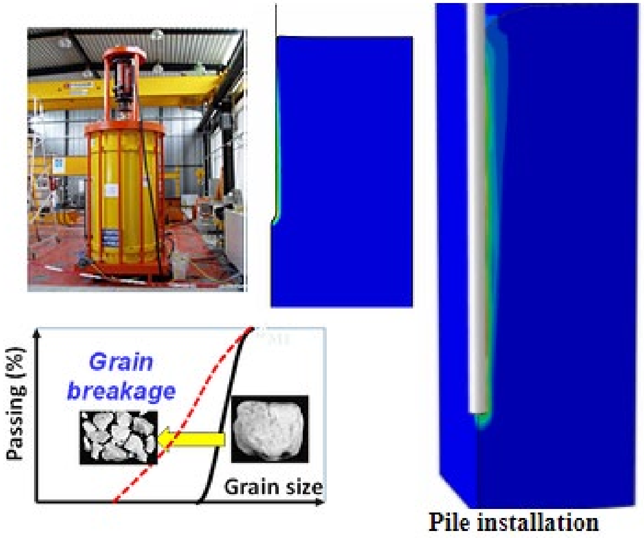
Multi-scale Modelling of Soils from Micro to Macro

The soil can be considered as a collection of grains or aggregates, and the stress-strain relationship for the assembly can be determined by integrating the behaviour of inter-grain/aggregate contacts in all directions. This micromechanical approach has advantages compared to the conventional modelling approach, i.e. the inherent or initial anisotropy of soils can be characterized by an orientation-dependence, which has a clear physical meaning and can be modelled in a direct way; adhesive forces, cementation can be considered at contact level; and so on.



Size Effects of Granular Materials & Engineering Application

For granular materials, samples with different grain sizes exhibit different deformability and strength. We have focused on investigating the size effect of granular materials in two aspects: under mechanical loading with significant grain crushing, the sample with bigger grain size has more deformability and less strength, whilst under mechanical loading with few or no grain crushing but significant shear band, the sample with bigger grain size has bigger strength. Our works include experimental study, discrete element modelling and continuum mechanics modelling up to the engineering application.



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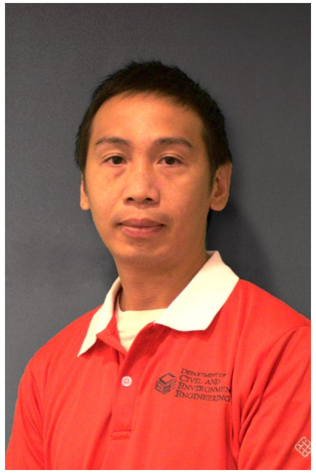

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(excluding Saturday, Sunday & public holidays)