ARUP

Instrumentation & Monitoring Procurement – HK Feedback

James Sze

28 November 2024

Agenda

ARUP

- Update of ELS Design and Control Practice in Hong Kong
- Instrumentation and monitoring procurement
- Case example of application of OM
- Ongoing and planned major infrastructure projects that have opportunities to apply OM

ARUP

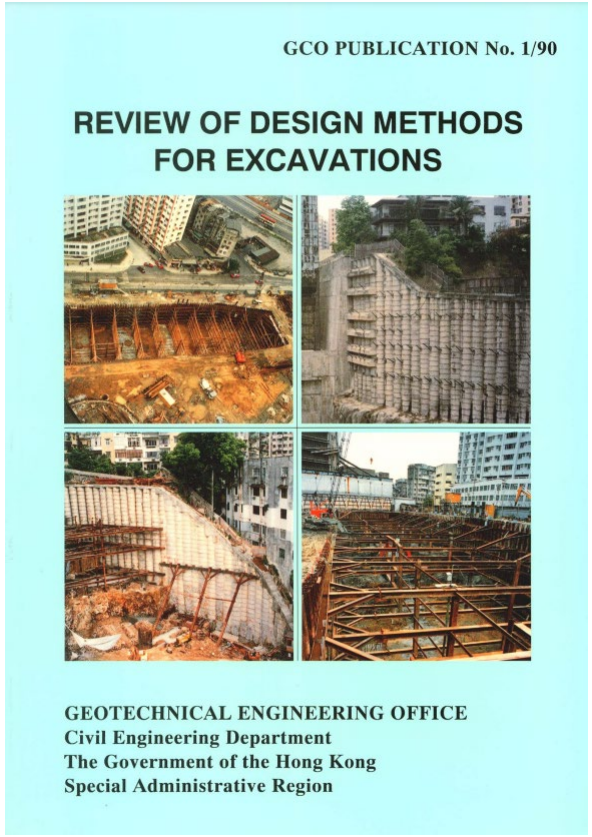
Hong Kong ELS Design Practice Update

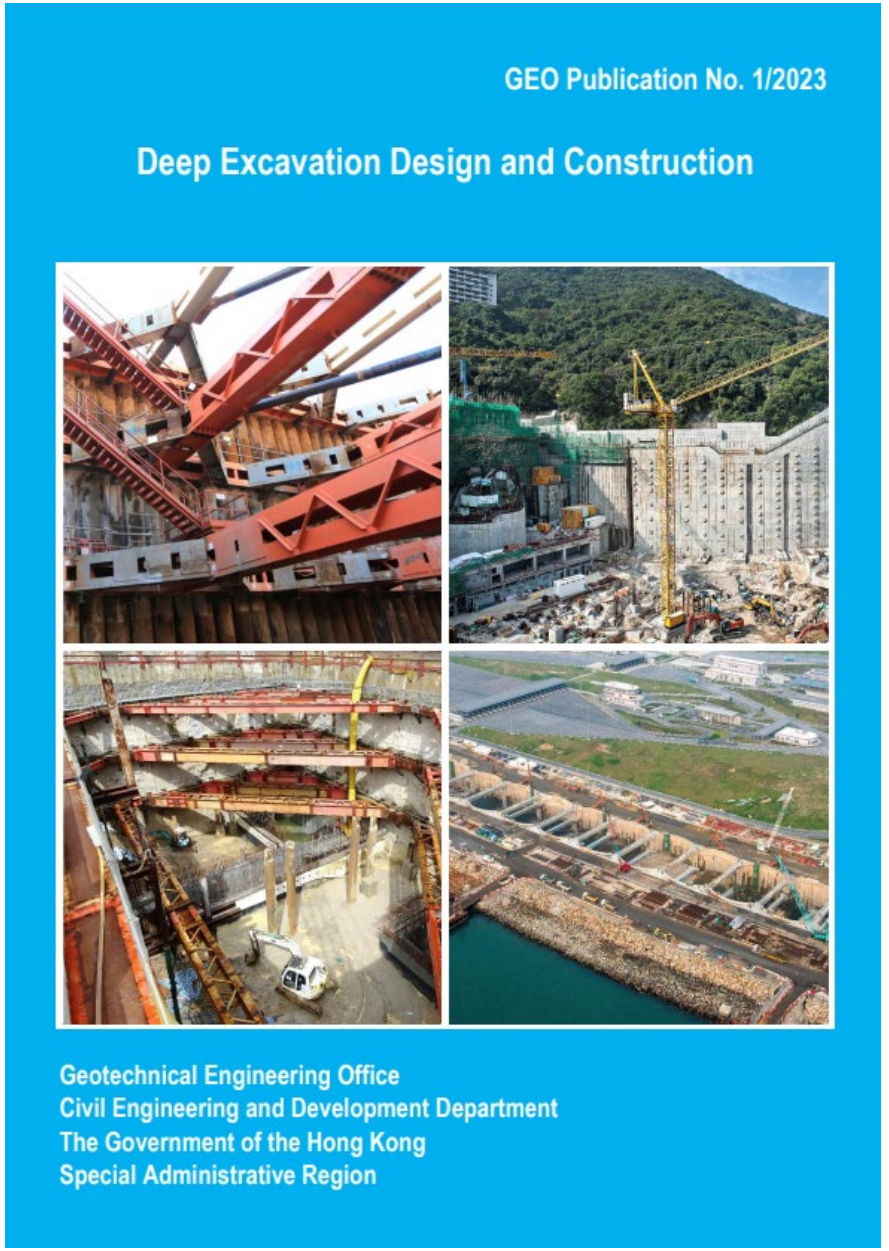
Revamped guidebook on Deep Excavation Design and Construction GEO Publication No. 1/2023

ARUP

- Published in December 2023
- Review design standards
- Recommend **practical** solutions
- **Rationalise** control mechanism

Aim to achieve economic designs of ELS works

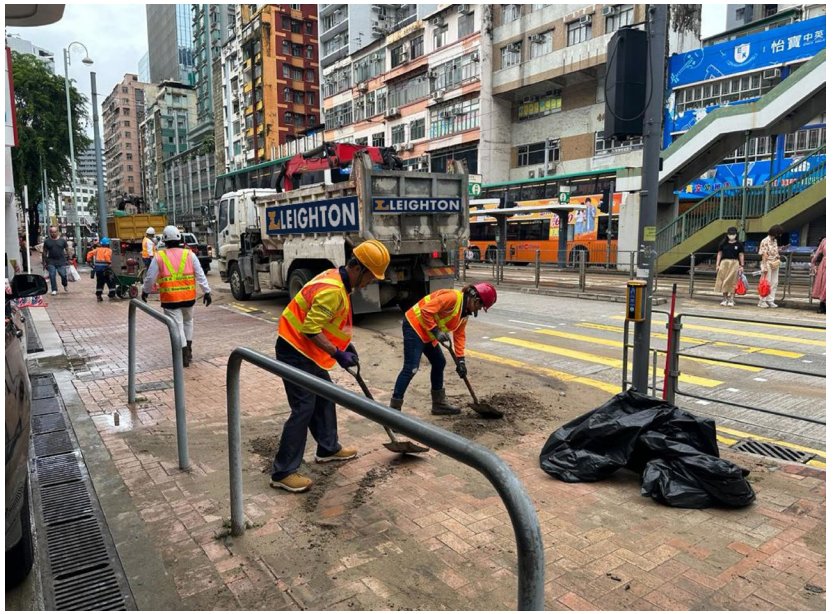




Enhanced Control Mechanism

ARUP

- **Separate the control mechanism** for serviceability and safety issues
- Take **pragmatic actions** to prevent suspension of works due to ground settlement
- Pre-plan to minimise disruption to public, e.g. **quick repaving of road surface and pavement** shall be carried out when reaching the Action Levels



What do various parties need to do ?

ARUP

- **Mutual trust** with the stakeholders to establish **realistic and practical** Action Levels

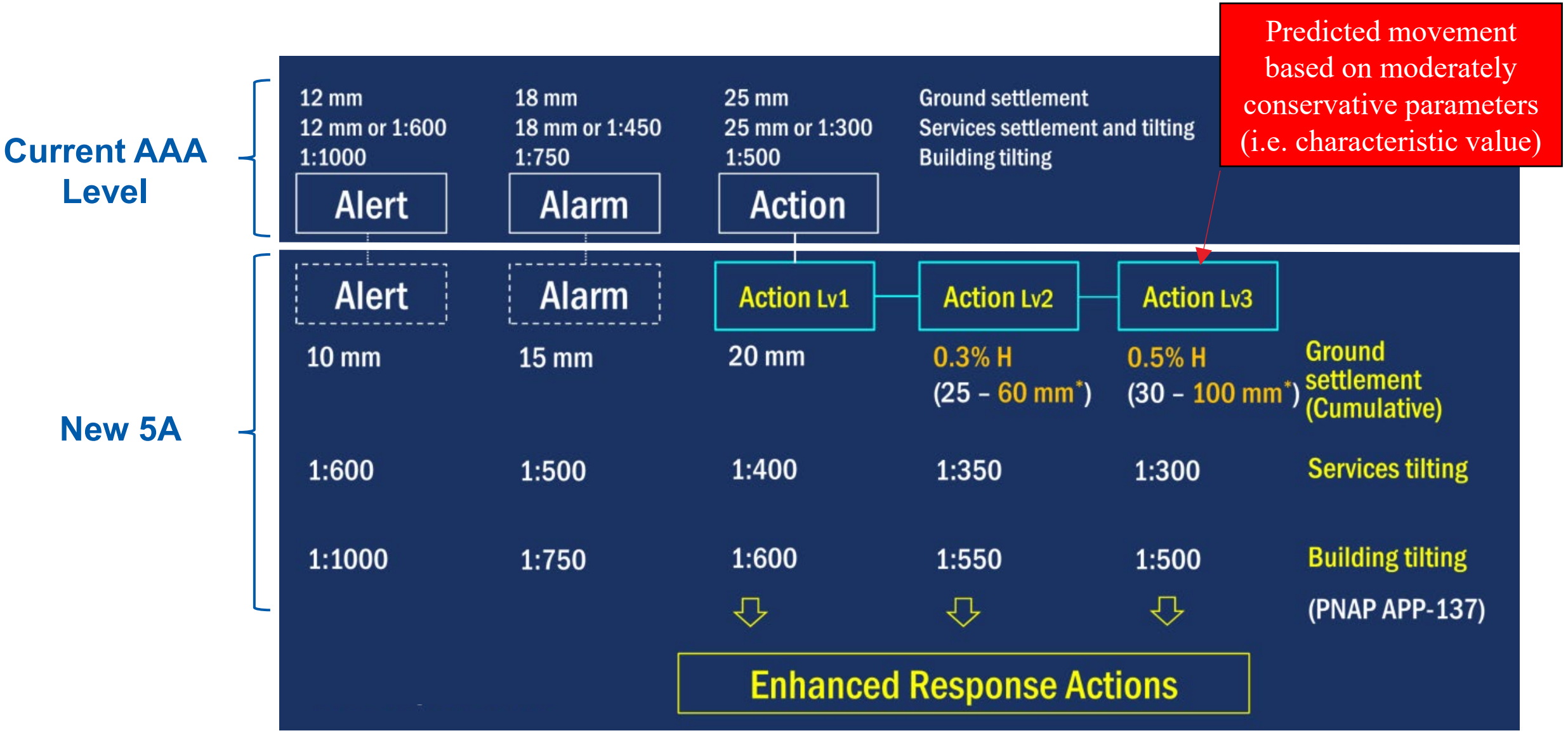
  (e.g. client's undertaking letter)
- **Communicate** with Utility undertakers, maintenance departments and authorities to agree on response actions at appropriate levels

  (e.g. prior agreement should be sought)
- **Plan ahead** and **take prompt action** to reduce serviceability issues and eliminate unnecessary suspension of works

  (e.g. contract provision for quick re-paving of road and pavement, etc)

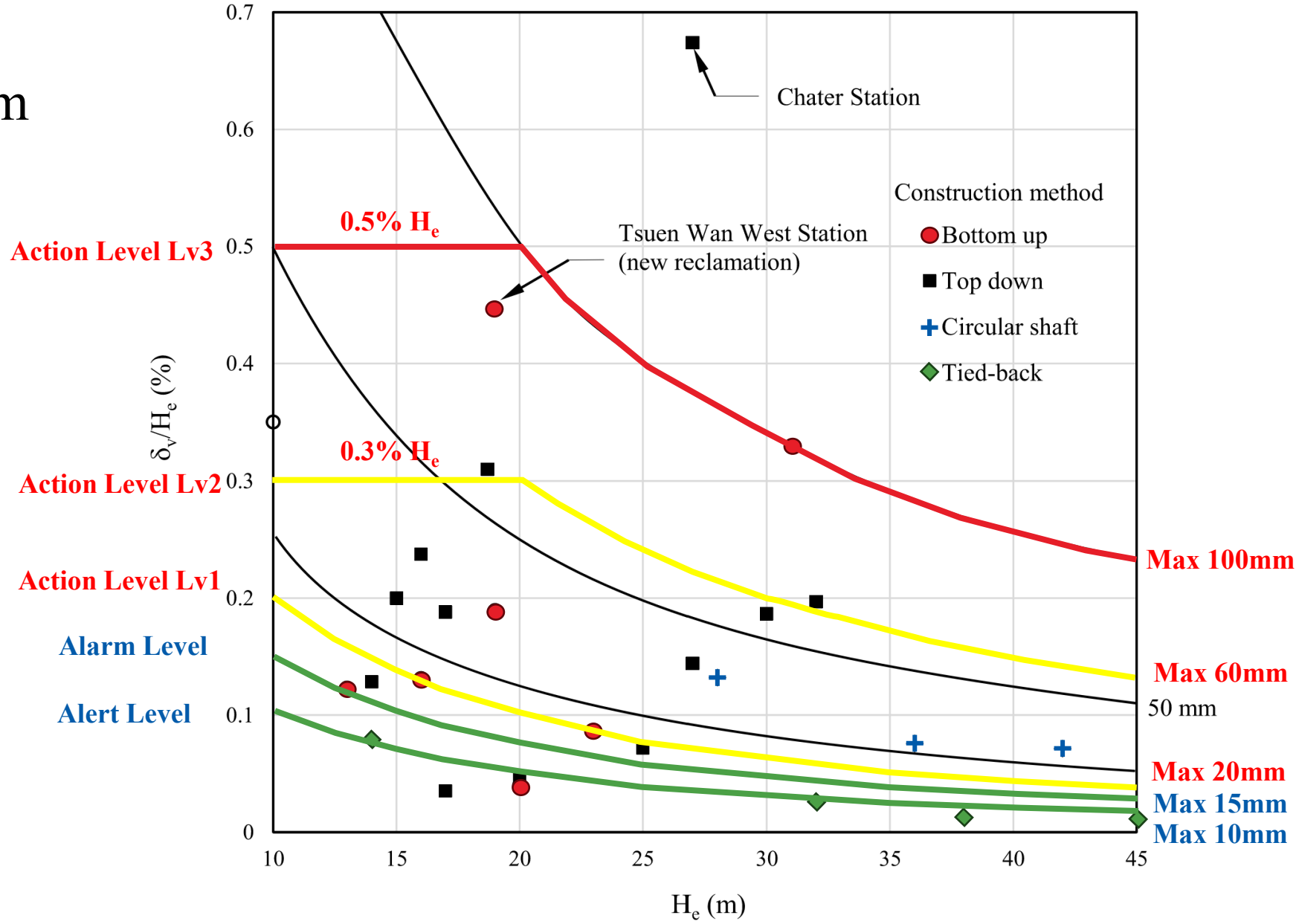
5-level (5A) Control Mechanism

ARUP



Historical representative data of total ground settlement vs maximum excavation depth

ARUP



Comparison with OM's Context

ARUP

Green

- Inspect and/or carry out condition survey if needed
- Prepare response plan & enhance monitoring if needed

Amber

- Carry out pre-determined actions including utility /road serviceability check & remedial /repairing works
- Carry out detailed investigation
- Formulate and carry out contingency plan for reaching Lv2
- Formulate emergency plan for reaching Lv3

Red

- Suspend works and formulate works resumption plan
- Carry out emergency plan if needed, condition survey & investigation
- Revise design & method statement
- Predict remaining movement & establish trigger values for further response action

0 to < 20mm | **20mm to < 0.5%H** | **≥ 0.5%H**

Alert	Alarm	Action Lv1	Action Lv2	Action Lv3	
10 mm	15 mm	20 mm	0.3% H (25 – 60 mm*)	0.5% H (30 – 100 mm*)	Ground settlement (Cumulative)
1:600	1:500	1:400	1:350	1:300	Services tilting
1:1000	1:750	1:600	1:550	1:500	Building tilting

ARUP

Typical Instrumentation & Monitoring Procurement Practice in Hong Kong

Instrumentation & Monitoring Procurement

ARUP

	MTRC Projects / large-scale infrastructure projects	Private Developments
Common contract type	• Design & build contract • NEC4 Option C • NEC4 Option X22	• Lump-sum / Remeasurement contract • Design & build contract
Responsible party for instrumentation and monitoring	• Contractor to install and monitor • MTRC's Consultant (or Contractor's Consultant for D&B contract) to supervise and check in routine basis	• Contractor to install and monitor • Client's Consultant to supervise and check in routine basis
Responsible party to design and review trigger levels	Project Registered Structural and Geotechnical Engineers (RSE & RGE) from MTRC/MTRC's Consultant (or Contractor's Consultant for D&B contract)	Project RSE/RGE from Client/Client's Consultant (For D&B contract, the Contractor's designer shall propose the trigger level for Project RSE/RGE to review & agree)
Independent checking / monitoring	MTRC engages independent monitoring consultants and contractors to carry out monitoring / independent checking	Not mandatory. For some clients, they may engage their in-house construction team to carry out independent checking. For projects falling within MTRC area, MTRC will engage independent monitoring contractor for joint survey
Data ownership	MTRC/Client	Client

Instrumentation & Monitoring Procurement

ARUP

	MTRC Projects / large-scale infrastructure projects	Private Developments
Common types of instruments	Tend to be more comprehensive and sophisticated, e.g. • settlement markers, • piezometers, • vibrograph, • tilt meters, • inclinometers, • extensometers (depends), • strain gauges, • ADMS with prisms, • real time monitoring, • Web-based digital platform and database	Tend to apply simple instruments, manual survey/ measurement, e.g. • settlement markers, • piezometers, • vibrograph, • tilt plates, • inclinometers (uncommon except diaphragm wall) ~~• extensometers,~~ ~~• strain gauges,~~ ~~• ADMS with prisms,~~ ~~• real time monitoring,~~ ~~• digital platform and database~~

ARUP

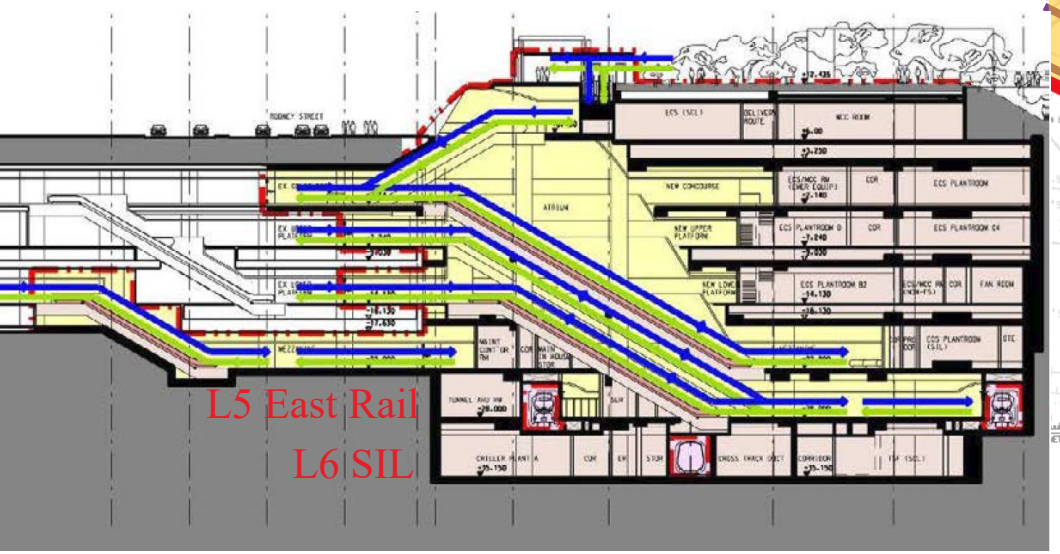
Case example

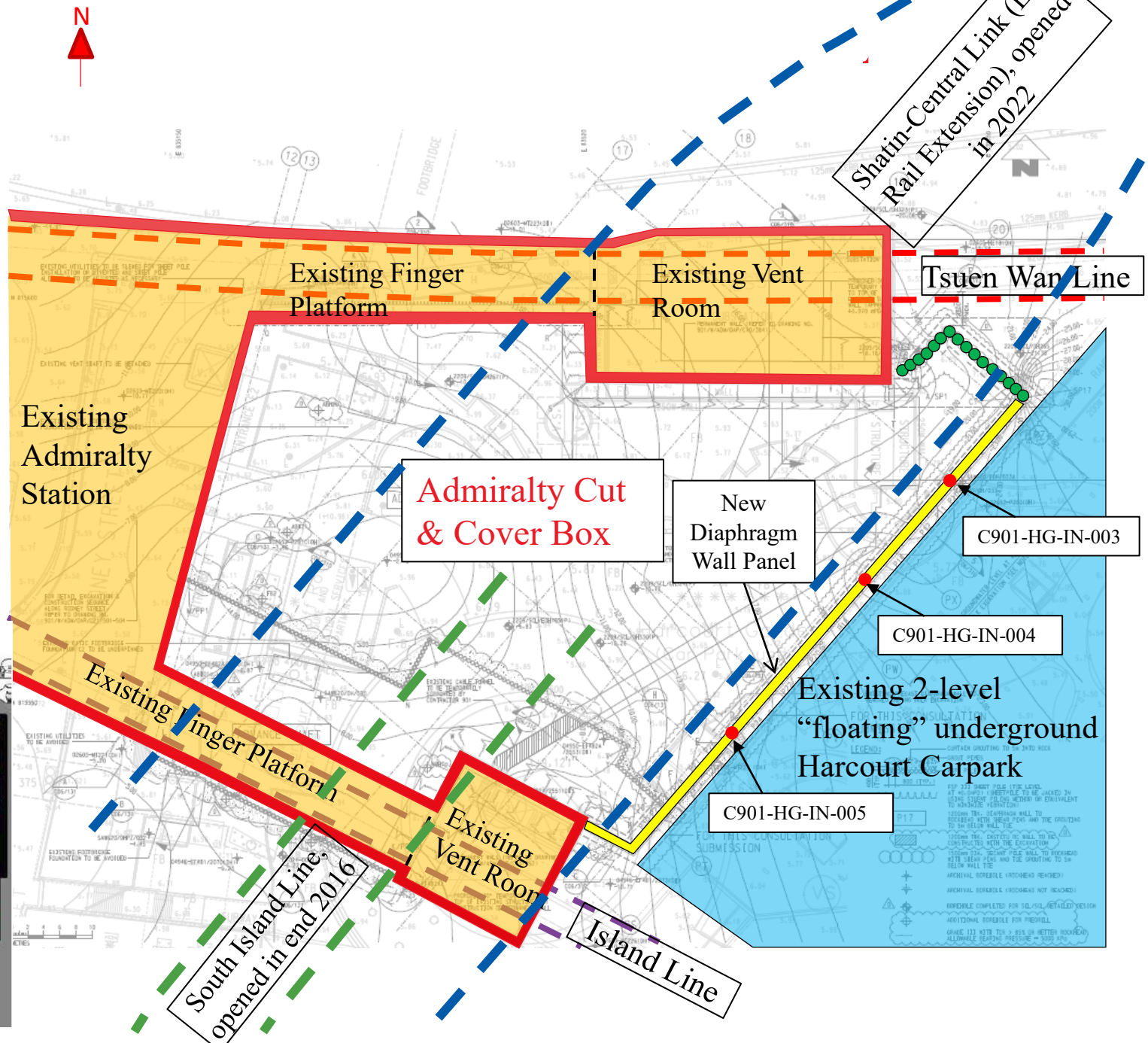
Excavation and Lateral Support Design for the New Admiralty Station Box


New Admiralty Station
Expanding existing underground 2-line interchanging station to accommodate another two new lines

New Admiralty Station

- Plan area ~90m x 74m
- 6-level, 45m deep excavation,
- Abutting existing station & existing underground carpark, underneath Island Line and Tsuen Wan Line tunnels
- Fast track



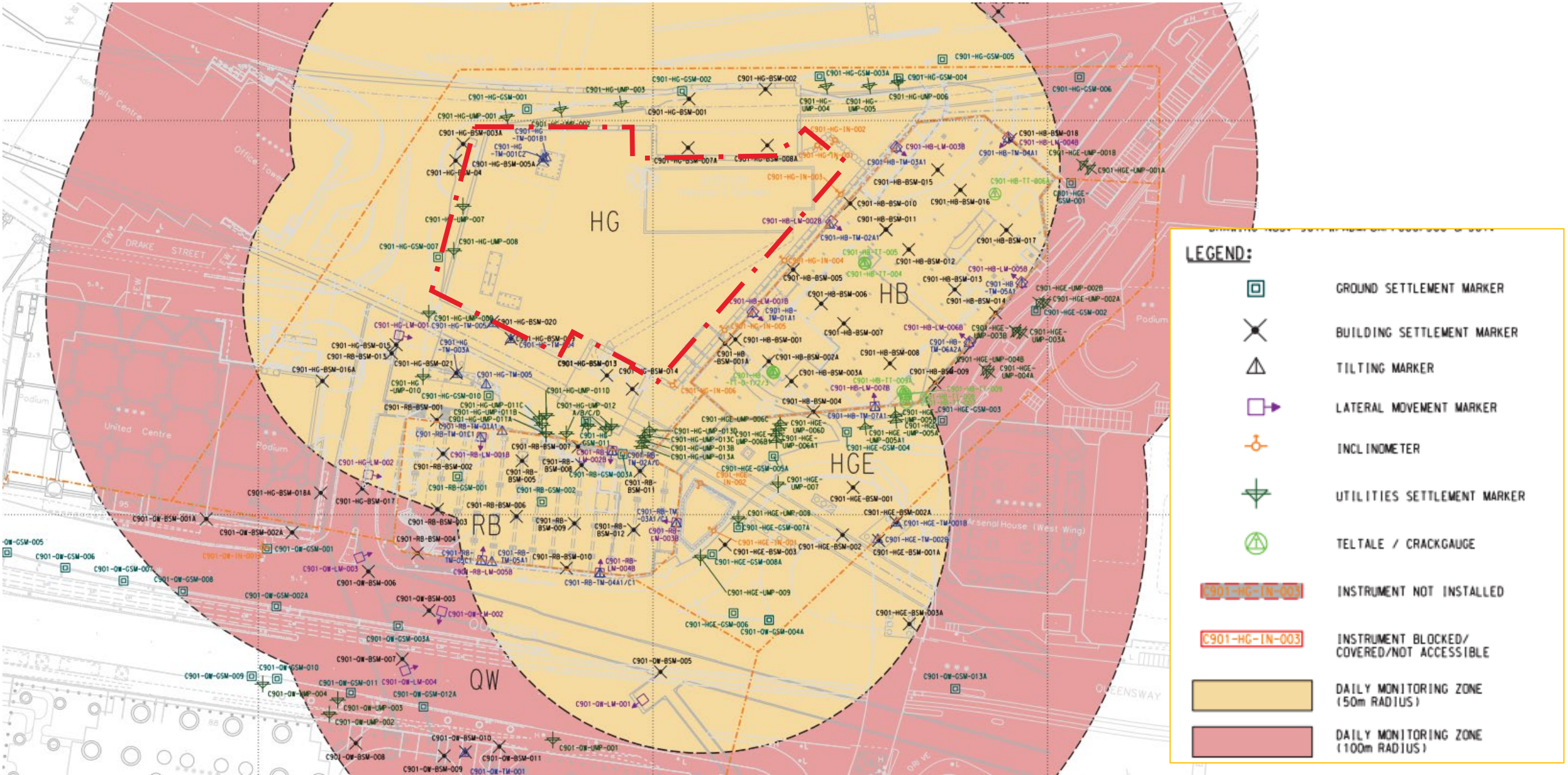


New Admiralty Station

ARUP

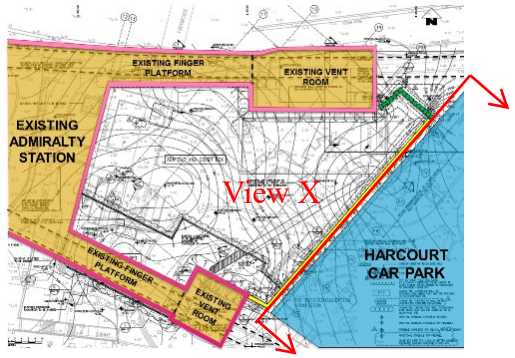
Instrumentation Plan

ARUP



Initial ELS design

ARUP



A

C901-HG-IN-003 | C901-HG-IN-004 | C901-HG-IN-005

Transfer Duct Slab +2.9

Concourse strut -2.49

Upper Track Slab -9.38

Ground Anchor -13.0

Lower Track strut -16.48

Toe Anchor -21.0

Top-down

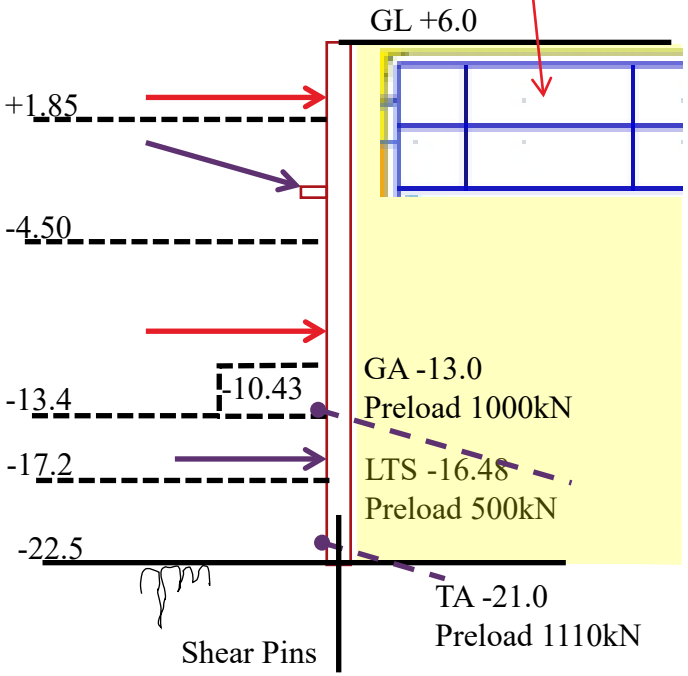
Bottom-up

-40mPD

A

View X

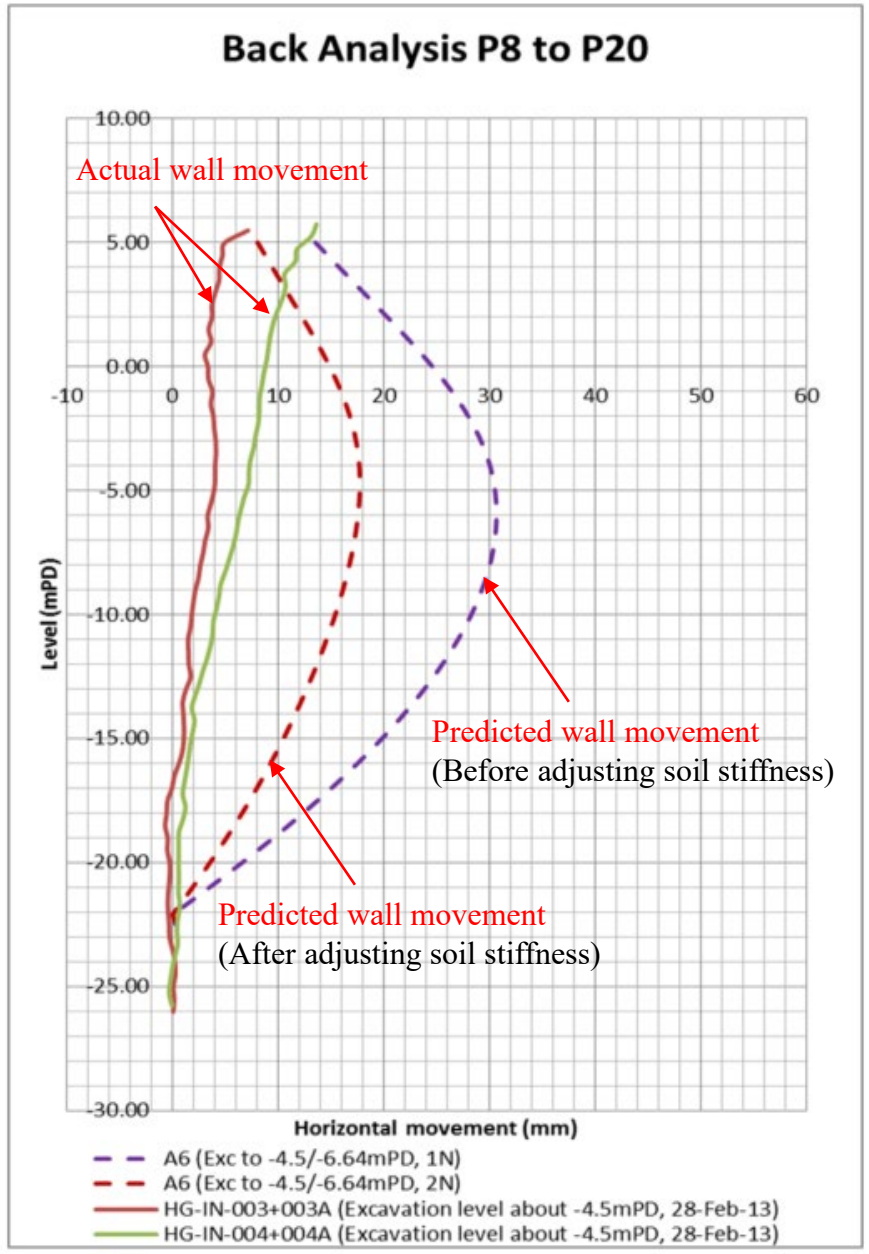
Existing 2-level "floating" underground Harcourt Carpark



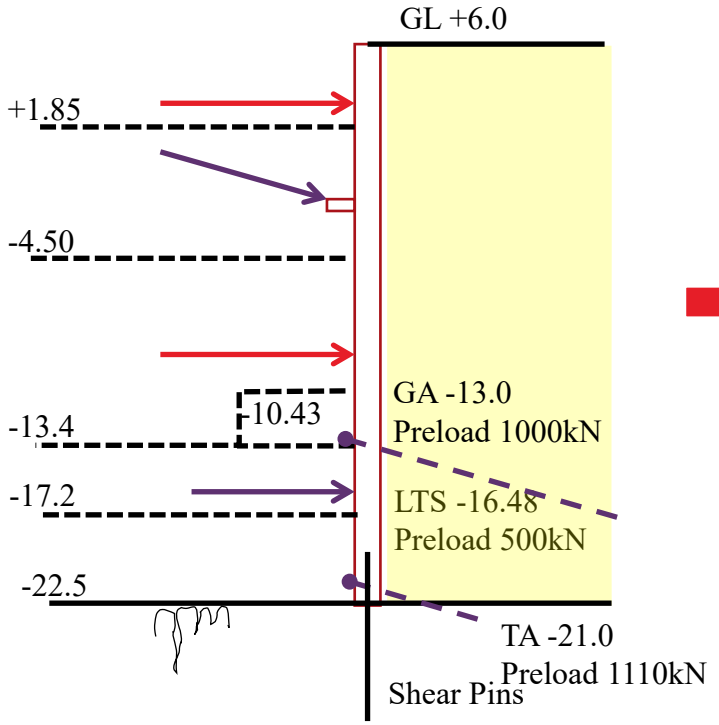
Section A

OM – Ipso tempore (Pro-active to make modifications)

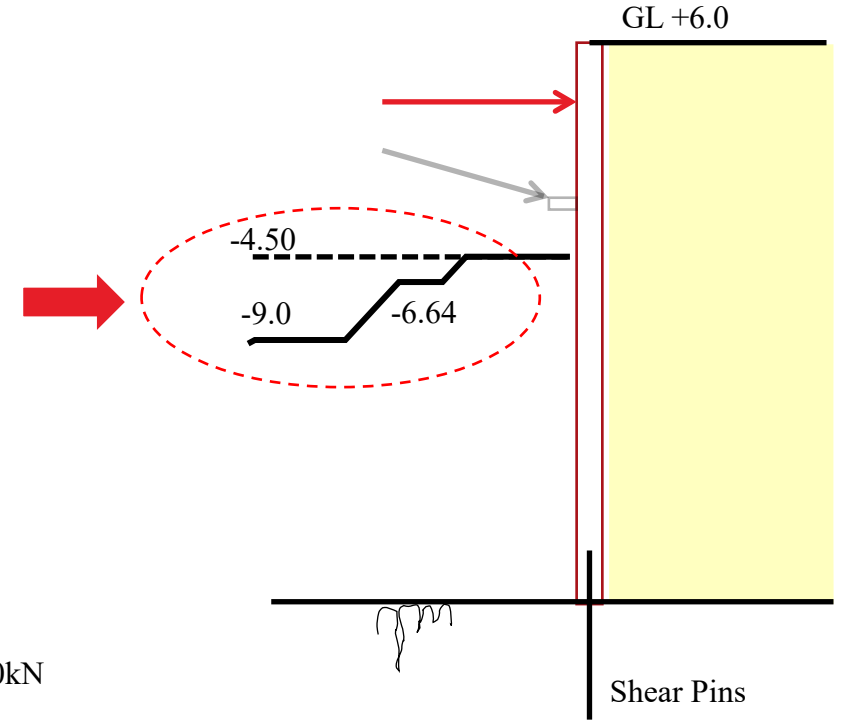
ARUP



- Back analysis based on inclinometer and ground settlement readings taking during excavation
- 1st Back Analysis (Exc. to -4.5mPD) → advance excavation at area beyond carpark side



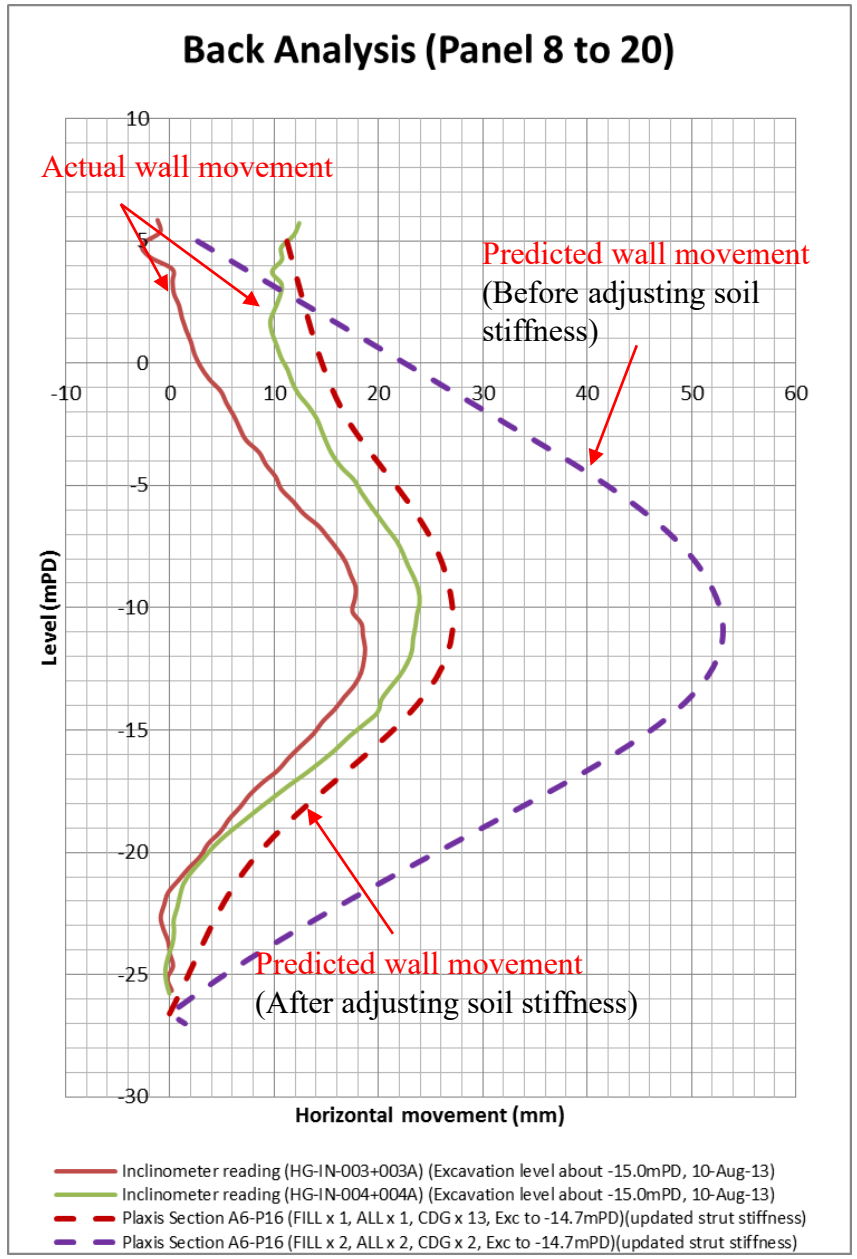
Initial ELS System



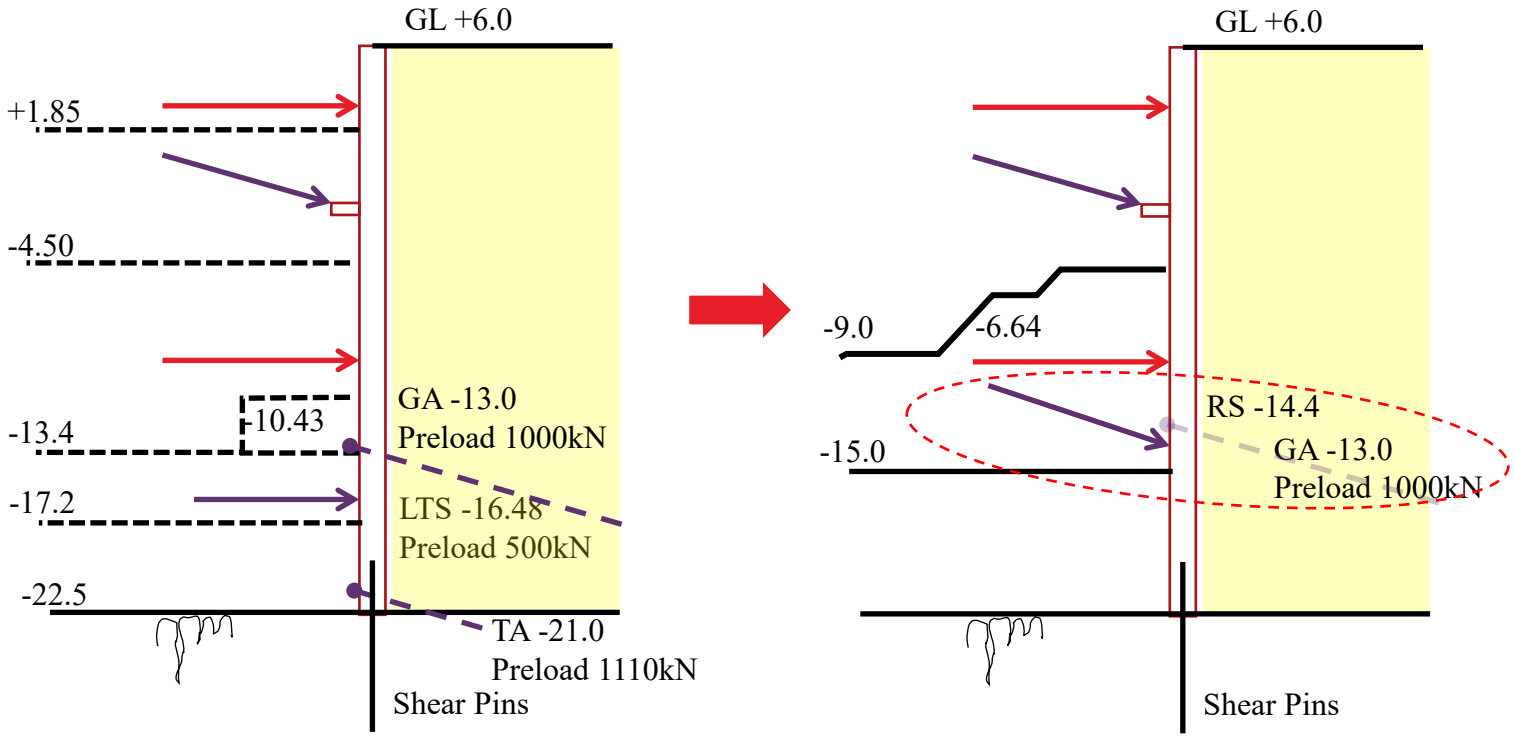
Optimised ELS System for this stage

OM – Ipso tempore (Pro-active to make modifications)

ARUP



- 2nd Back Analysis (Exc. to -15mPD) → ground anchor at -13mPD replaced with internal inclined strut

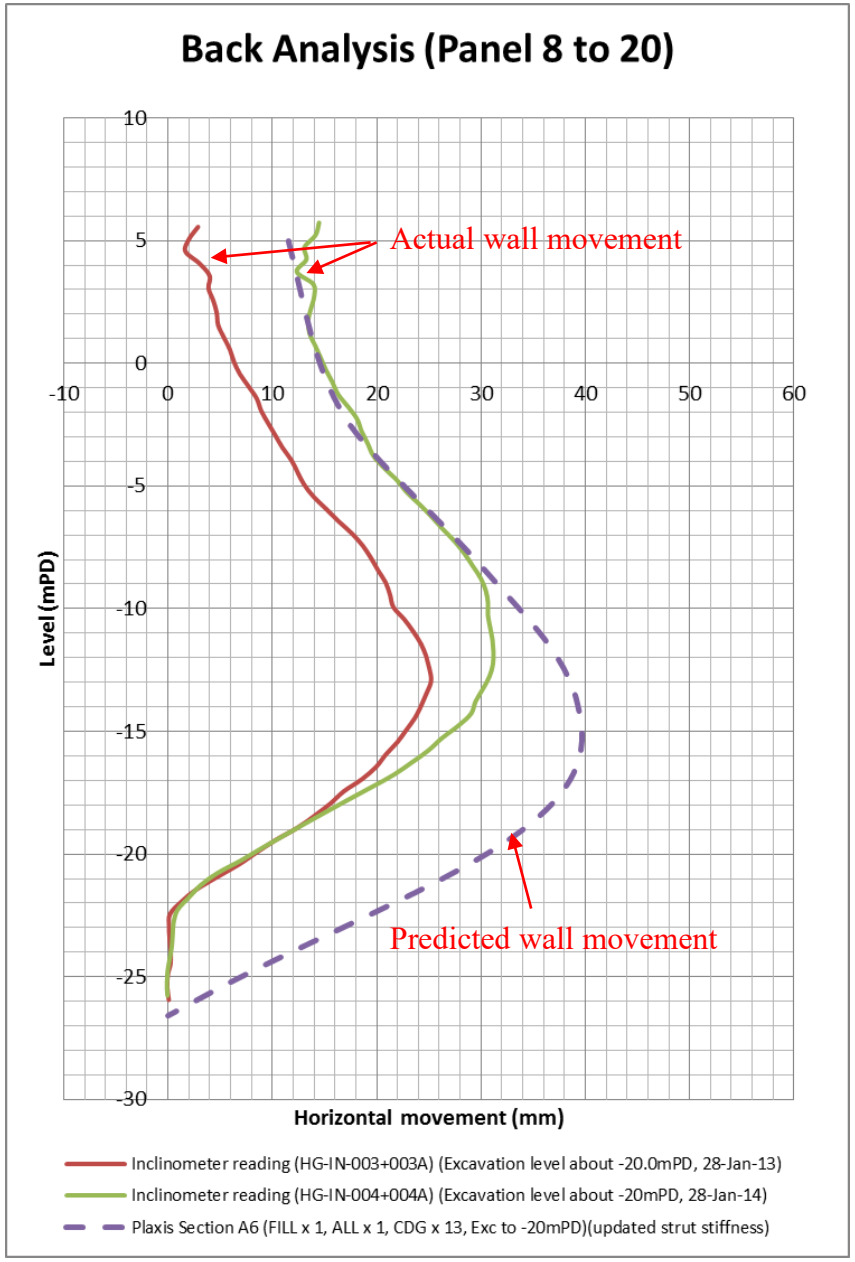


Initial ELS System

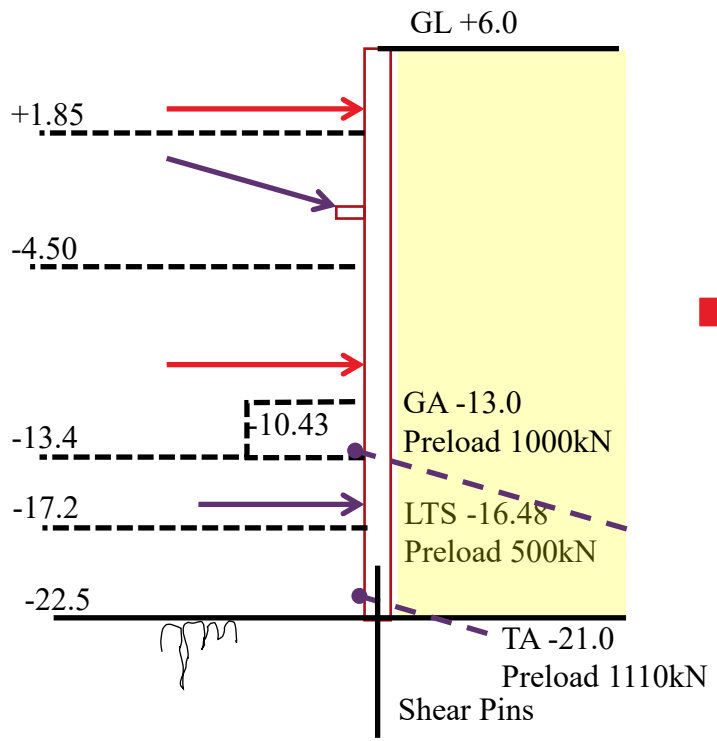
Optimised ELS System for this stage

OM – Ipso tempore (Pro-active to make modifications)

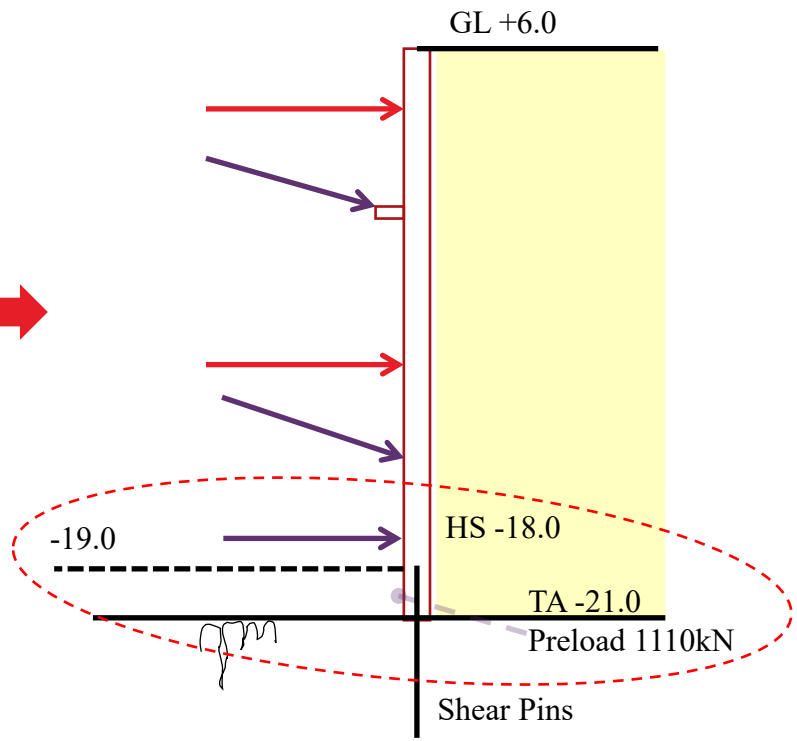
ARUP



- 3rd Back Analysis (Exc. at -19mPD) → toe anchor @-21mPD eliminated. Strut at -16.5mPD slightly adjusted to -18.0mPD



Initial ELS System



Optimised ELS System for this stage

ARUP

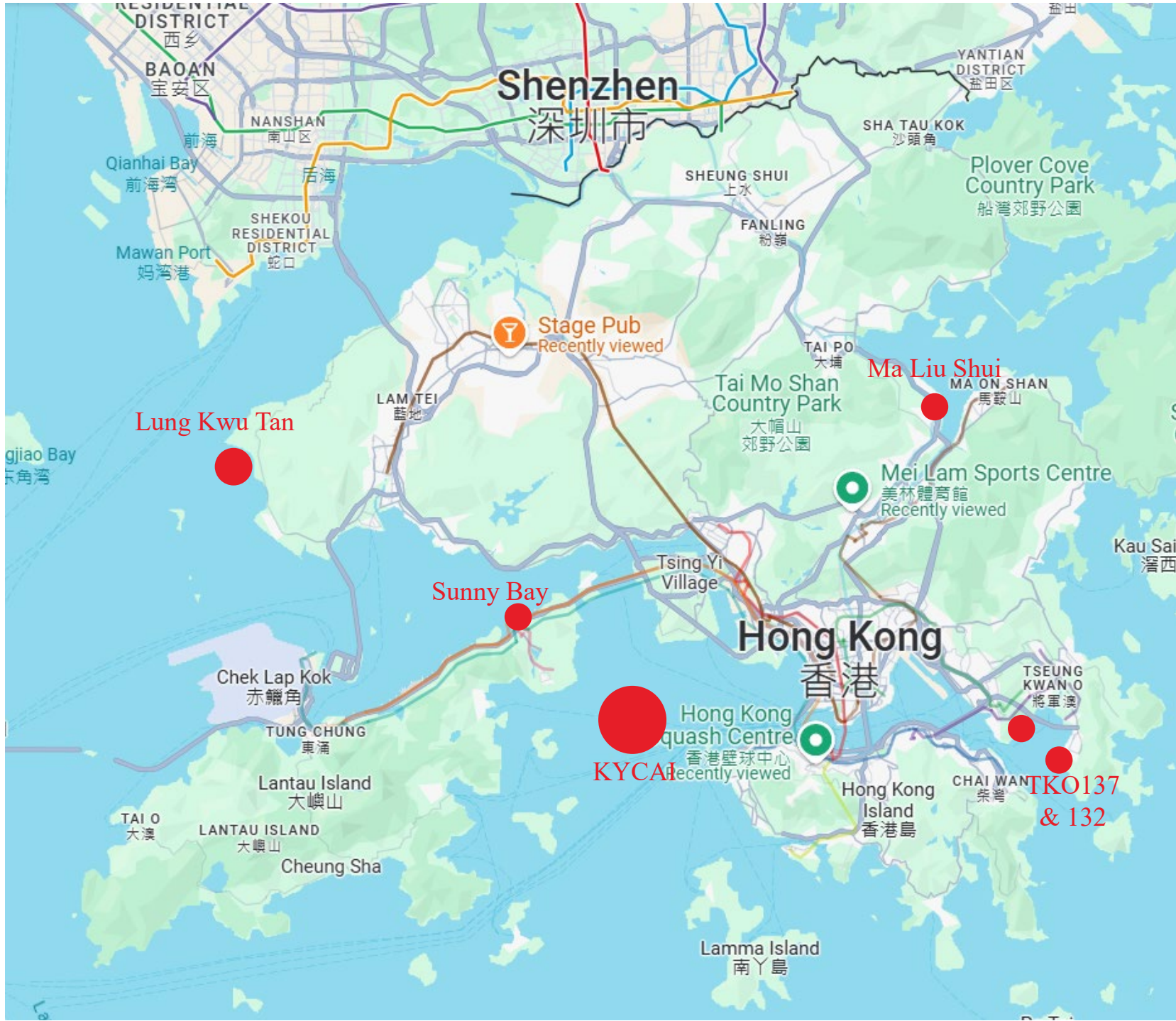
On-going & Planned
Major Infrastructure Projects in Hong Kong

Recent Major Reclamations in HK

ARUP

Future reclamation projects

- Tseung Kwan O 137 & 132 – 80ha
- Kau Yi Chau Artificial Islands – 1,000ha
- Lung Kwu Tan – 150ha
- Ma Liu Shui – 90ha
- Sunny Bay – 100ha



On-going & future underground Railways

- Tung Chung Line Extension (2.5km)
- Northern Link (11km)
- Hong Kong-Shenzhen Western Rail Link (8km)
- TKO line extension (2km)
- Priority Rail Link for KYCAI (30km)
- Central Rail Line (16km)

Underground major road tunnels

- Northern Metropolis Highway (18km, expected substantial tunnel sections)
- Route 11 tunnel section (~10km)
- Tuen Mun Bypass (8km)
- Shatin Bypass (15km)

ARUP

Thank You