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Hong Kong Housing Authority

Precast Concrete Construction and MiC for Public Housing Developments

by

Rayson W H WONG

(Chief Structural Engineer)

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Innovative Construction Methods for Public Housing Developments 2021

HA's Precast Concrete Components

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Enhanced Precast

1980s – 90s	2000 – 2017	2019 ~ NOW
 Precast Staircase	 Volumetric Precast Bathroom (VPB)	 Volumetric Precast Kitchen (VPK)	 Semi-precast Corridor Slab
 Precast Concrete Façade (PCF)	 Precast Acoustic Balcony	 Precast Half Landing	 Precast Lift Shaft
 Semi-precast Slab	 Precast Roof Elements (e.g. water tank)	 Precast Partition Wall	 Precast Structural Wall (with concealed conduit)
 Precast Beam			

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Precast Concrete Components (PCCs)

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Precast Water Tank


Precast Parapet

At the Main Roof


Precast Façade


Precast Tie Beams


Precast Staircase


Precast Half Landing

Volumetric Precast Bathroom/Kitchen (VPB+VPK)

Precast Drywall (Building Component)


Precast Partition Wall

Semi-Precast Slab

Precast Balcony

Insitu Concrete

Precast Concrete Components (inside domestic flat)

Precast Concrete Components (common area)

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Volumetric Precast Concrete Components

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With Finishes and BS Components starting *from 2000 onwards*

Volumetric Precast Kitchen (VPB)

Volumetric Precast Kitchen (VPK)

Volumetric Acoustic Balcony

Lift Shaft

Staircase Half Landing

Water Tank

Enhanced Precast Concrete Components (EPCCs)

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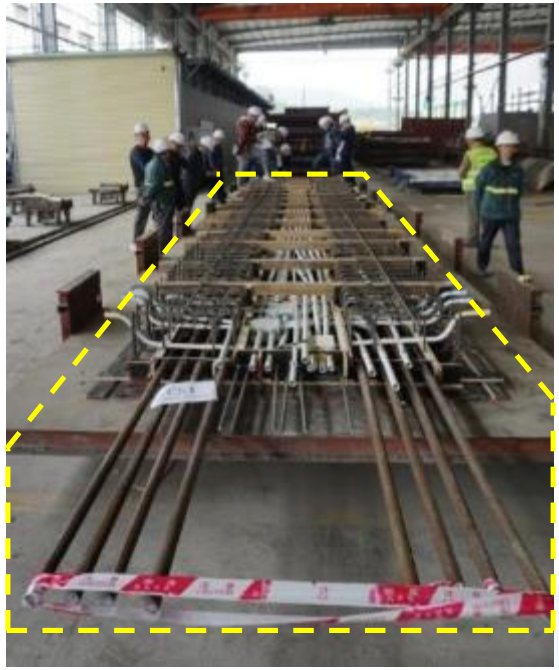
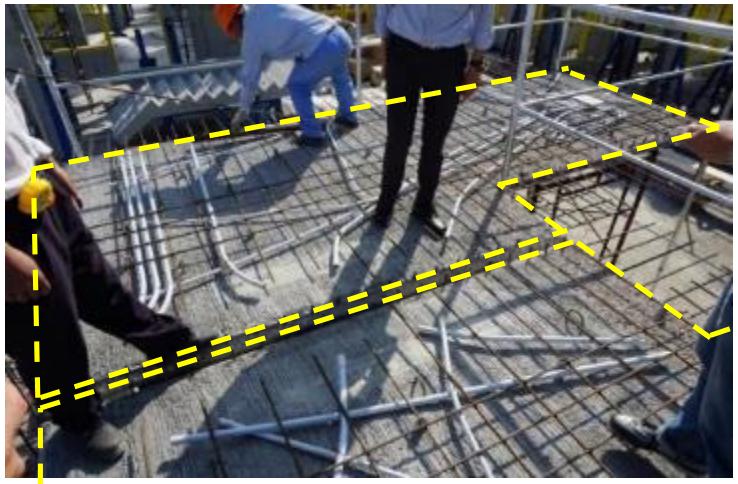


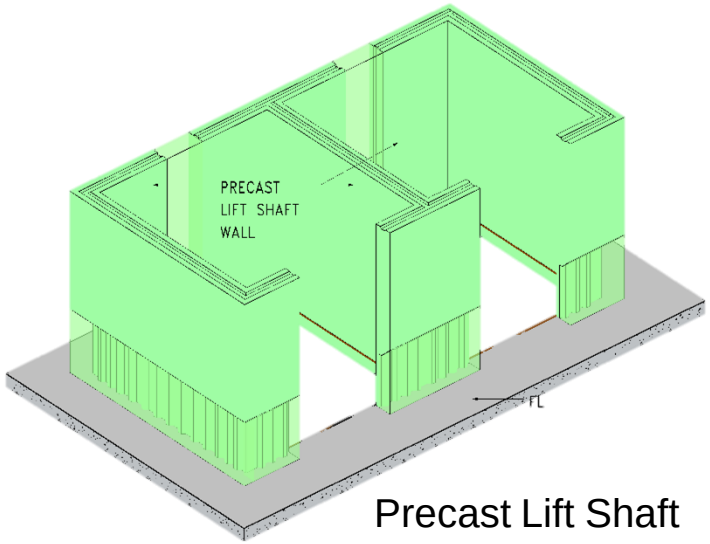
Enhanced Semi-precast
Corridor Slab



Enhanced Semi-precast Slab

- Comprising **corridor slab, domestic flat slab, structural wall** and **lift shaft**.
- Adopted for building contracts since **Feb 2020**.

Precast Structural Wall



Precast Lift Shaft

Evolution of Precast Concrete Components in HA

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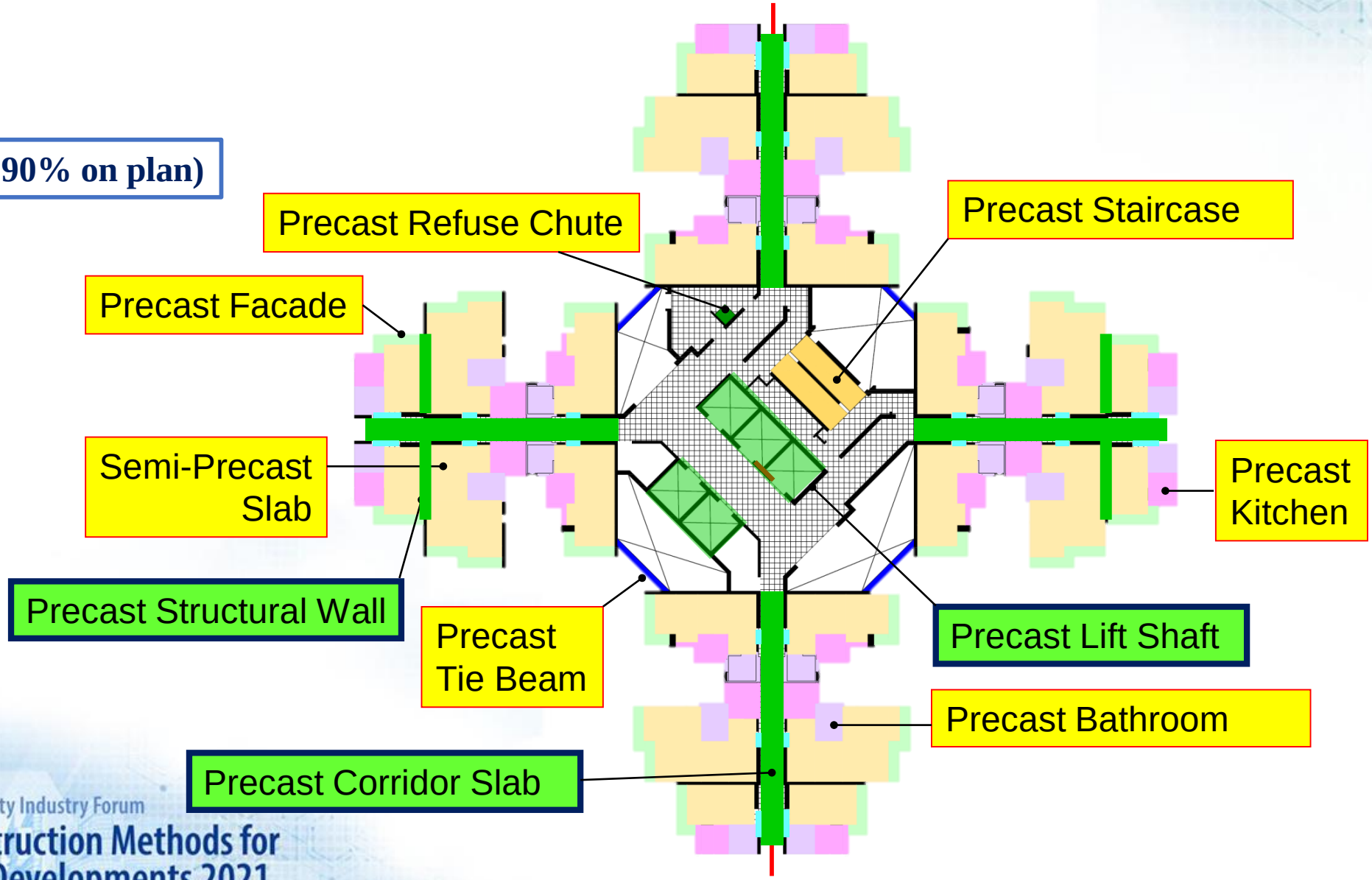
(Precast Rate ~ 90% on plan)



Precast Concrete Components (PCCs)

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Precast Water Tank


Precast Parapet

At the Main Roof


Precast Tie Beams


Precast Façade


Precast Staircase


Precast Half Landing

Volumetric Precast Bathroom/Kitchen (VPB+VPK)

Precast Drywall (Building Component)


Precast Partition Wall

Semi-Precast Slab

Precast Balcony

Insitu Concrete

Precast Concrete Components (inside domestic flat)

Precast Concrete Components (common area)

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Typical Construction Programme for a 40-storey block

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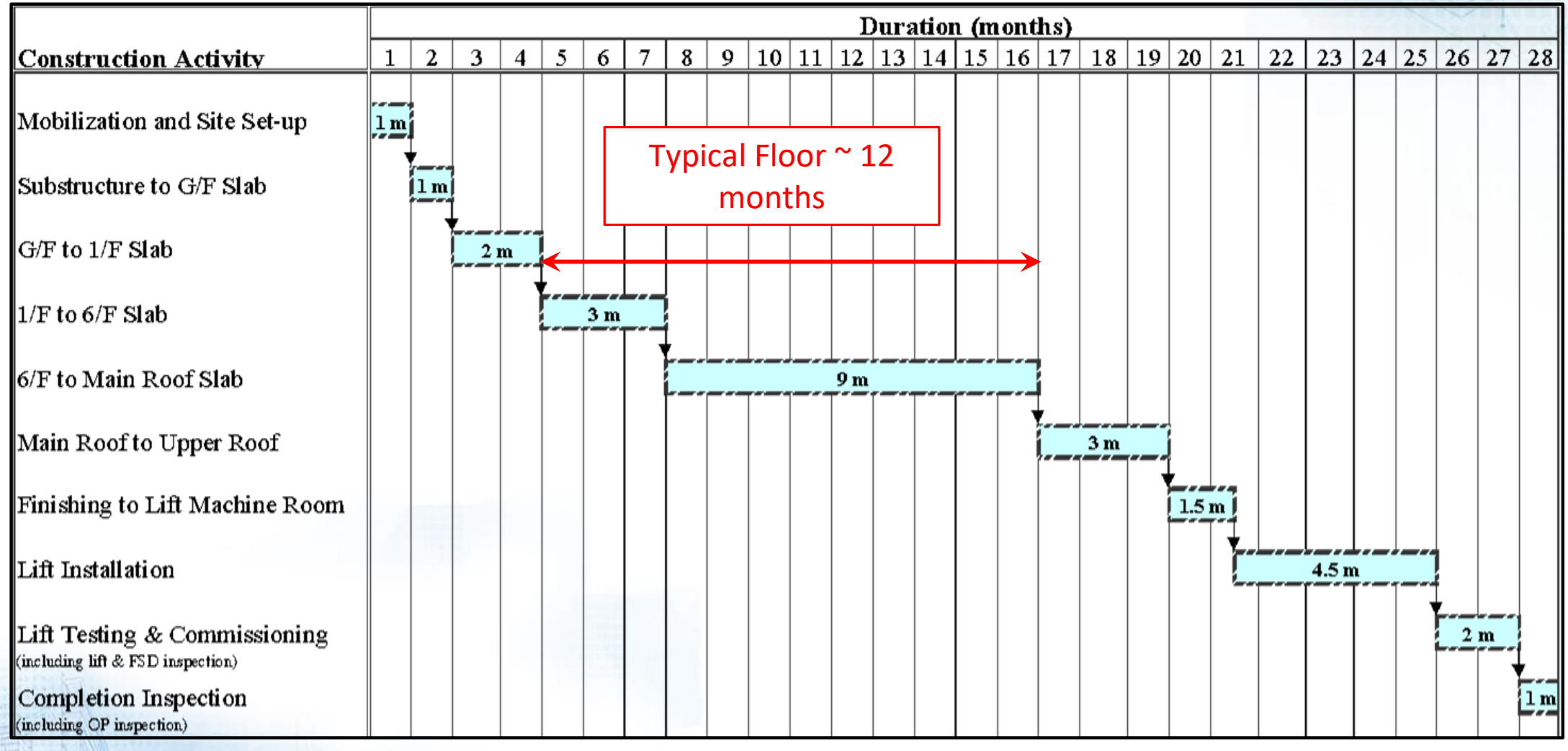

Volumetric Precast Lift Machine Room (VPLMR)

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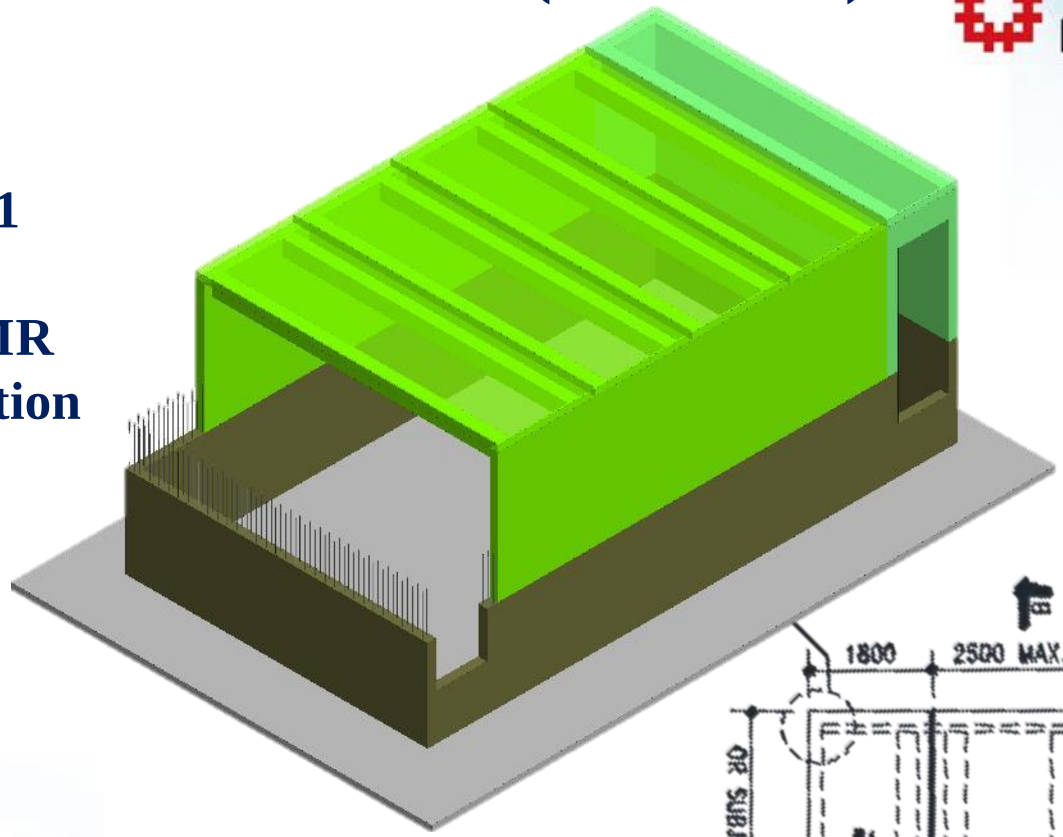
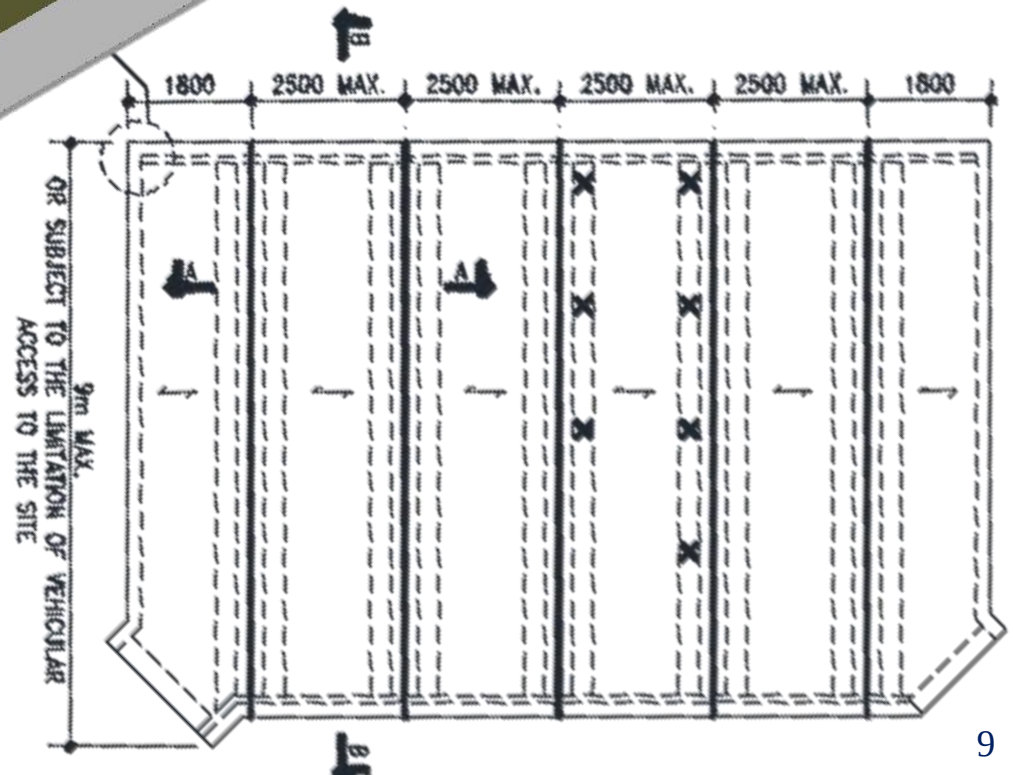
- Mandate to use since early 2021
- Allow earlier completion of LMR and the subsequent lift installation works
- Avoid extensive formwork and falsework and the subsequent removal works





External Works Precast Elements

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Precast Manhole

Precast Cable Drawpit

Precast Surface Channel

List of Precast Concrete Components (PCCs) in HA

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PCCs adopted at TYPICAL FLOOR

1) Precast Façade
2) Semi-Precast Slab
3) Precast Concrete Wall between Kitchens
4) Volumetric Precast Bathroom
5) Volumetric Precast Kitchen
6) Precast structural wall

MiC

7) Precast Staircase
8) Precast lift shaft
9) Semi-precast corridor slab
10) Precast Half-landing
11) Precast Acoustic Balcony
12) Precast Partition Wall
13) Precast Beam
14) Precast Refuse Chutes

PCCs adopted at ROOF & G/F

15) Precast Roof Parapet
16) Precast Roof Water Tank
17) Precast Roof Staircase
18) Precast Panel Wall for Lift Machine Room at Main Roof
19) Semi-precast Roof Slab
20) Precast Ground Floor Water Tank
21) Precast Segmental Water Tank

PCCs adopted at EXTERNAL AREA

22) Precast Manhole / cable drawpit at external area
23) Precast Surface Channel
24) Precast Hoarding
25) Precast Footing
26) Precast Hard Paving

MiC Application in HA

Modular Integrated Construction (MiC)

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MiC - Background

A construction method whereby –

a) Free-standing volumetric modules (with finishes, fixtures, fittings, etc.)
b) Manufactured off-site
c) Transported to site for assembly

Buildings Department	Practice Note for Authorized Persons, Registered Structural Engineers and Registered Geotechnical Engineers	ADV-36

Modular Integrated Construction

Introduction

Modular Integrated Construction (MiC) refers to a construction method whereby free-standing volumetric modules (with finishes, fixtures, fittings, etc.) are manufactured off-site and then transported for constructing buildings. Proven benefits include improved site safety, more efficient and better quality control, shortened construction period, less construction waste, less demand for on-site labour, less disturbance and nuisance to the neighbourhood, etc., not just contributing to the quality and sustainable built-environment but also help ease some of the challenges of the local construction industry. To encourage MiC, the Buildings Department (BD) has formulated streamlined measures and guidelines to facilitate the industry in meeting the relevant standards and requirements under the Buildings Ordinance (BO).

PNAP ADV-36, Buildings Department, https://www.bd.gov.hk/english/documents/pnap/ADV/ADV036.pdf

https://www.bd.gov.hk/english/inform/index_mic.html

Modular Integrated Construction (MiC)

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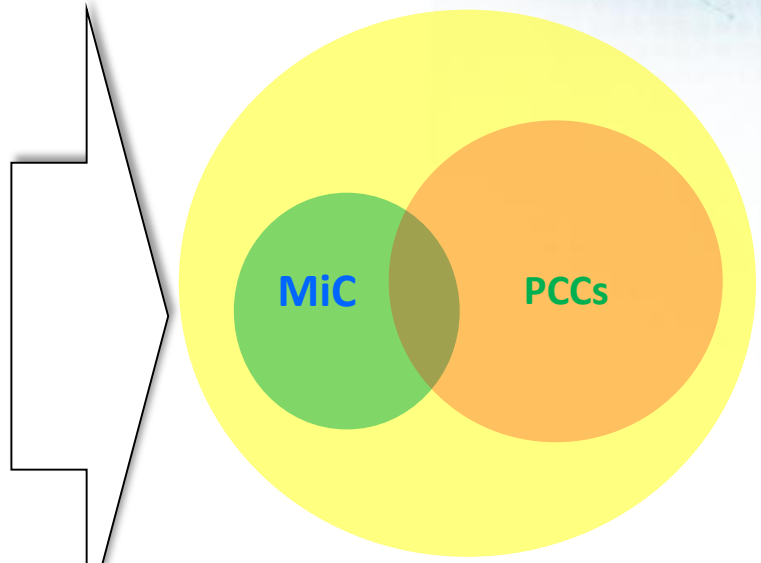
MiC and HA PCCs

- **MiC (also PCCs of HA)** is a kind of **Off-site Prefabrication under DfMA**
- **PCCs** and MiC both share the *similar advantages* such as productivity, quality, safety and environmental friendliness
- Under PNAP-ADV36, MiC qualifies to achieve 6% GFA concession should be –
  - ✔ **free-standing** volumetric modules ;
  - ✔ with **finishes, fixtures, fittings**, etc.; and
  - ✔ manufactured **off-site** and then transported for site assembly.
- Volumetric PCCs with fittings e.g. VPB, VPK, are also MiC



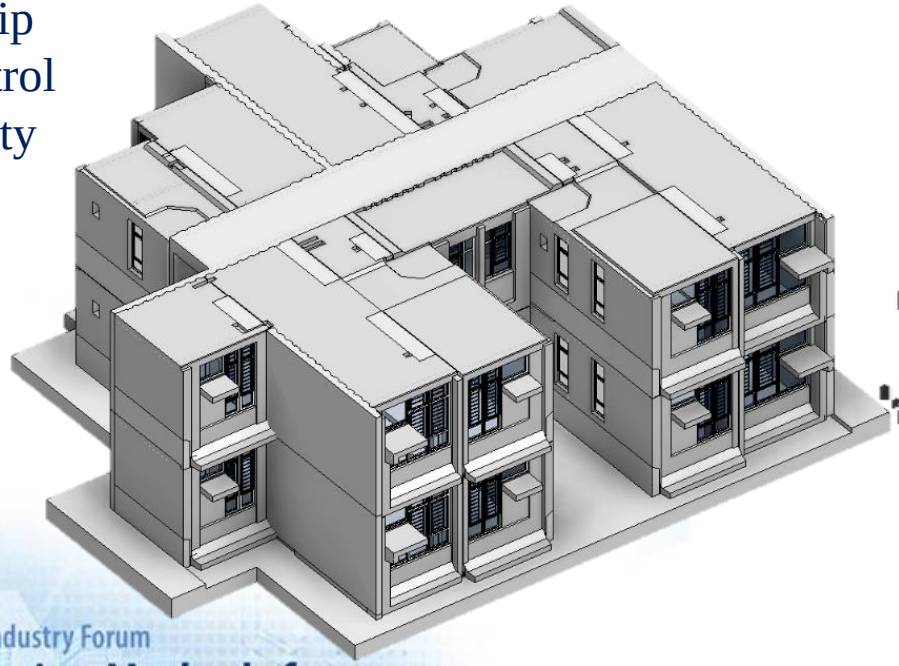
Off-site Prefabrication

Volumetric Precast Bathroom / Kitchen (VPB/VPK)

MiC Mock-up

- **2 storeys / 4 Types** of Modular Flats
- Total **8 flats** (**22 modules**)
- Fabricated in 惠州
- Commencement - **9 / 2020**
- Completion - **12 / 2020**

- Assessment of –
  - buildability
  - workmanship
  - quality control
  - joint integrity



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MiC Mock-up

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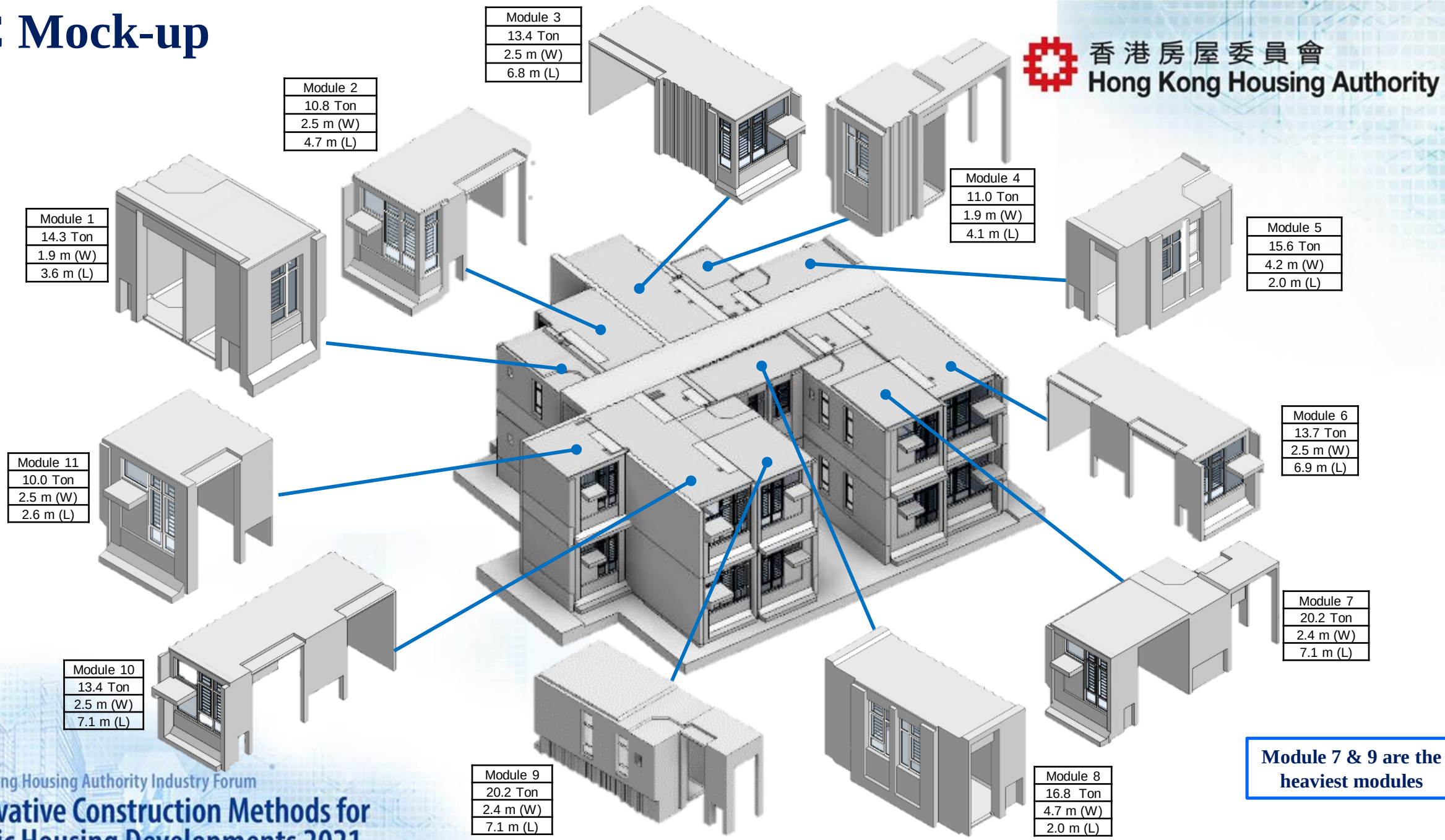

Module 7 & 9 are the heaviest modules

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Note: All modules are NOT more than the transportation limit of 2.5m width

MiC Mock-up

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- **Completed in Dec 2020**

MiC in Public Housing Developments

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(1) Precast Factory Capacity

- Six active factories currently providing PCCs to HA

  (Few have concrete MiC experience)
- Require upgrading of hoisting gantries
- Large storage for modules

Main Contractor	MiC Supplier	Project
Shui On JV	China State Hailong	Residential Care Homes for the Elderly ("RCHE") in Kwu Tung North (8-storey)
Yau Lee	Yau Lee Wah	Disciplined Services Quarters for FSD at Pak Shing Kok in TKO (16/17 -storey)
Yau Lee	Yau Lee Wah	Yen Chow Street Modular Social Housing Project

Significant investment for factory to produce MiC modules

MiC in Public Housing Developments

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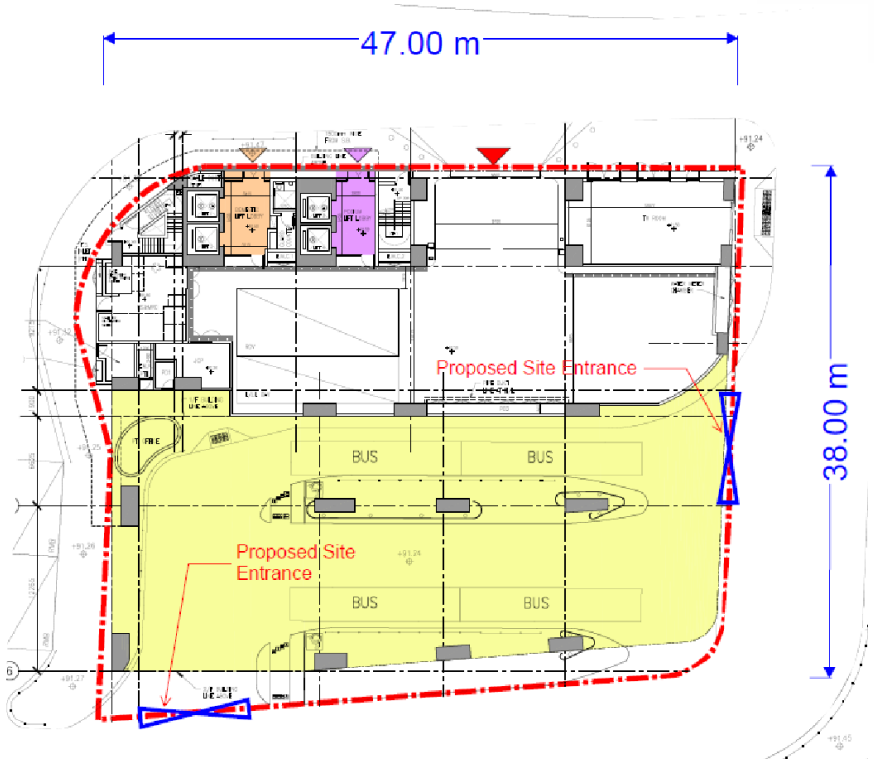
(2) Site Storage

- Congested sites with limited temporary storage area for large scale MiC modules.



Limited site storage for HA's developments

MiC in Public Housing Developments

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(3) Construction Vehicle Restriction

- Nearby **site constraints** and **road access restriction** (e.g. narrow road) hinder the delivery of MiC modules.

MiC in Public Housing Developments

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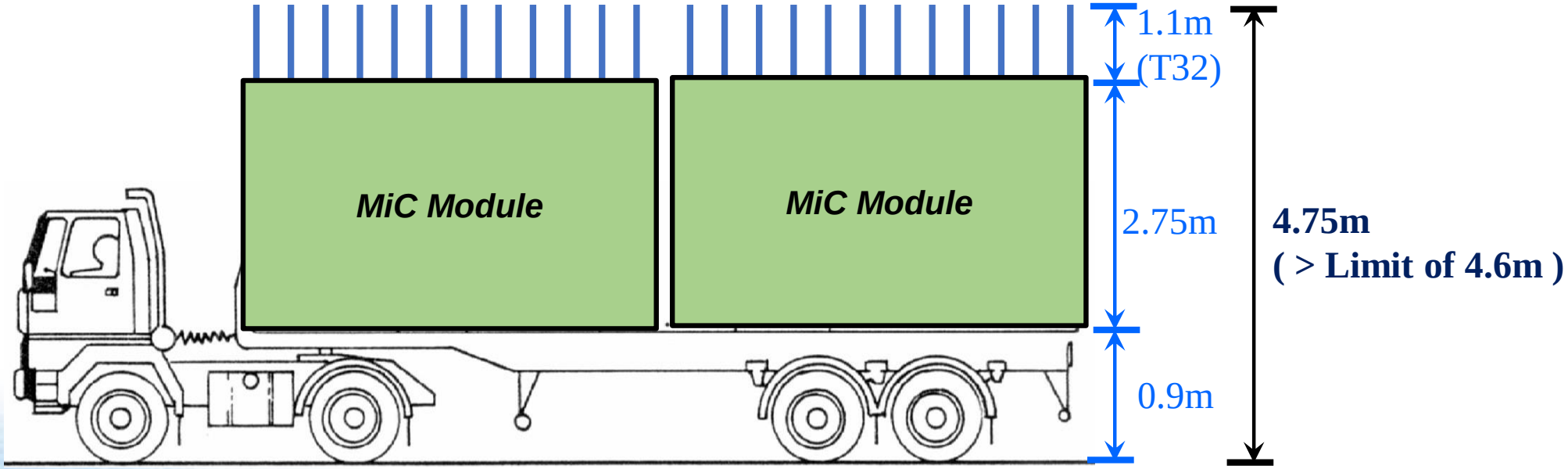
(3) Construction Vehicle Restriction (Cont'd)

- Cap 374G Road Traffic (Traffic Control) Regulation 55
- Height not exceeding 4.6m
- Starter bar < 32dia.



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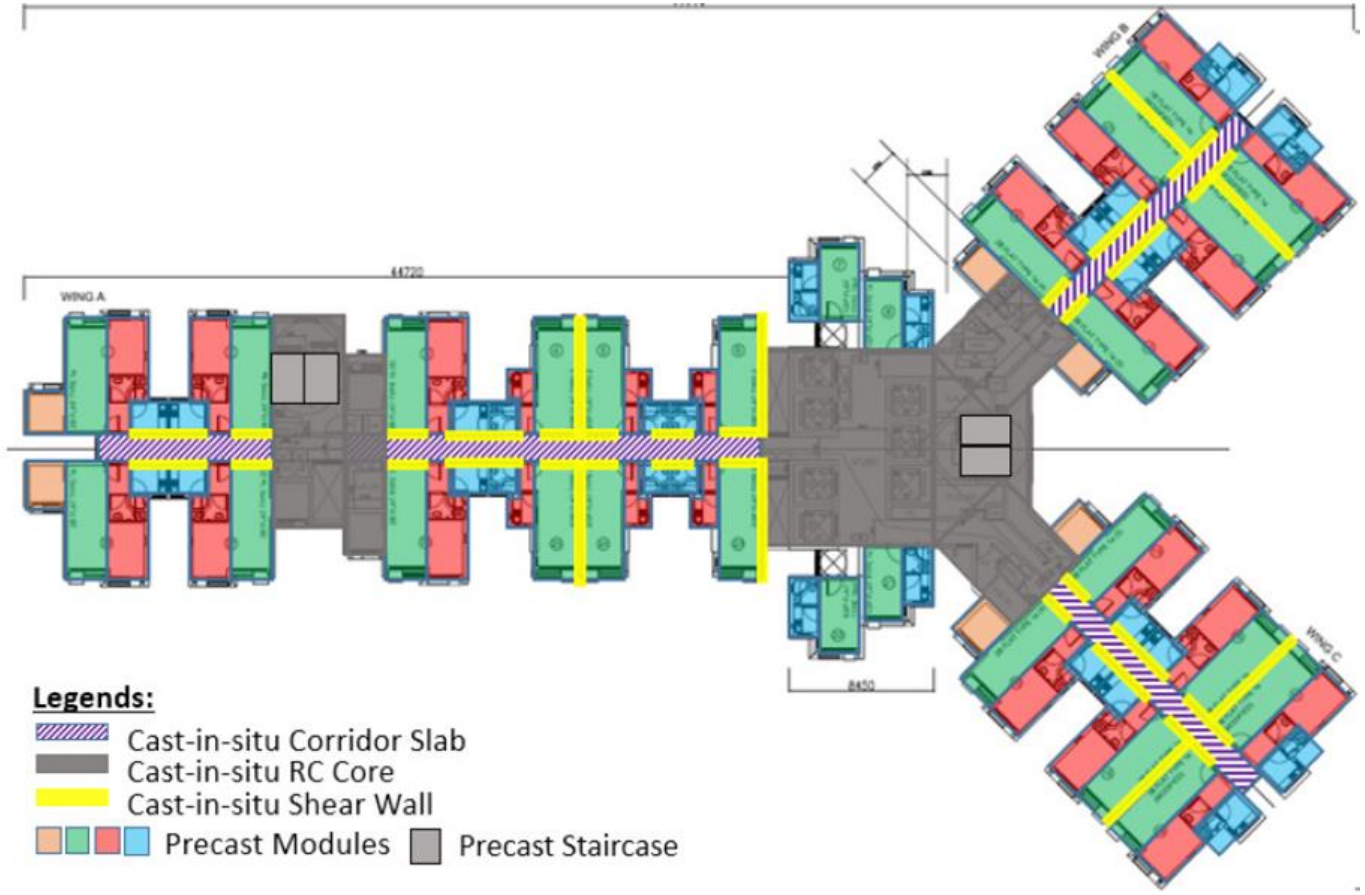
(4) Large Footprint of Public Housing Developments

- Public housing blocks generally have more than 20 flat units (70 to 100 modules).
- Lifting and installation of MiC modules are crucial for domestic block to maintain the current **6-day construction cycle**.



MiC in Public Housing Developments

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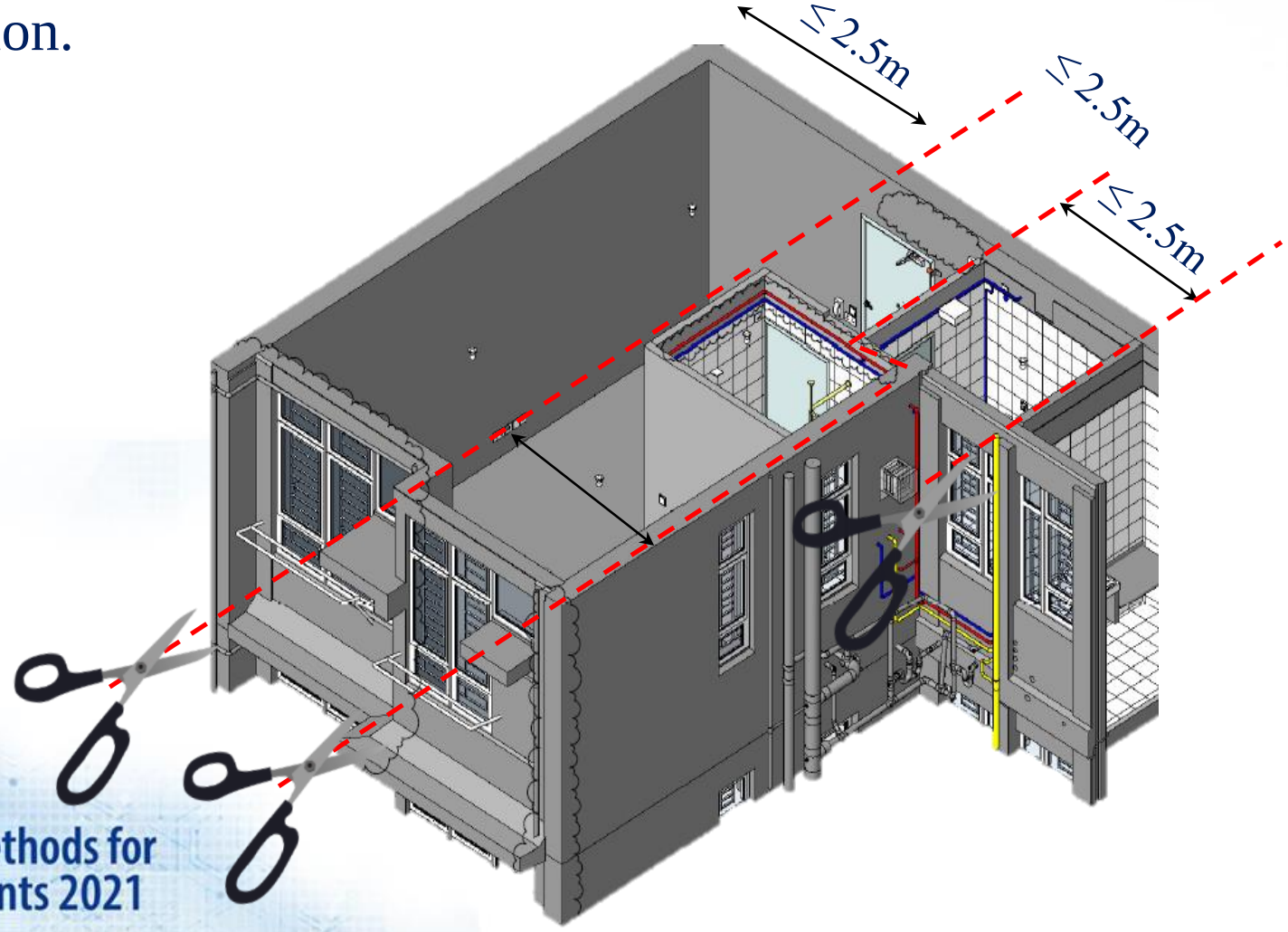
(5) Size of Module

- HA's modular flat to be sub-divided into modules to suit the 2.5m width limit for transportation.



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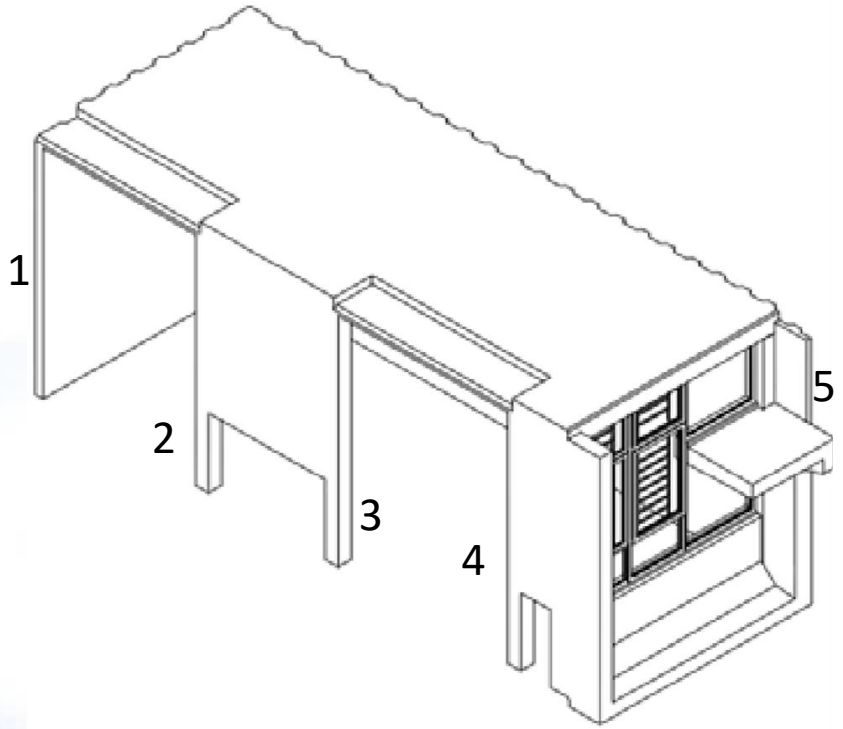
(6) Dimensional Tolerance Control

- High precision control for multi-face connection.
- Longer installation time compare with smaller modules.



MiC in Public Housing Developments

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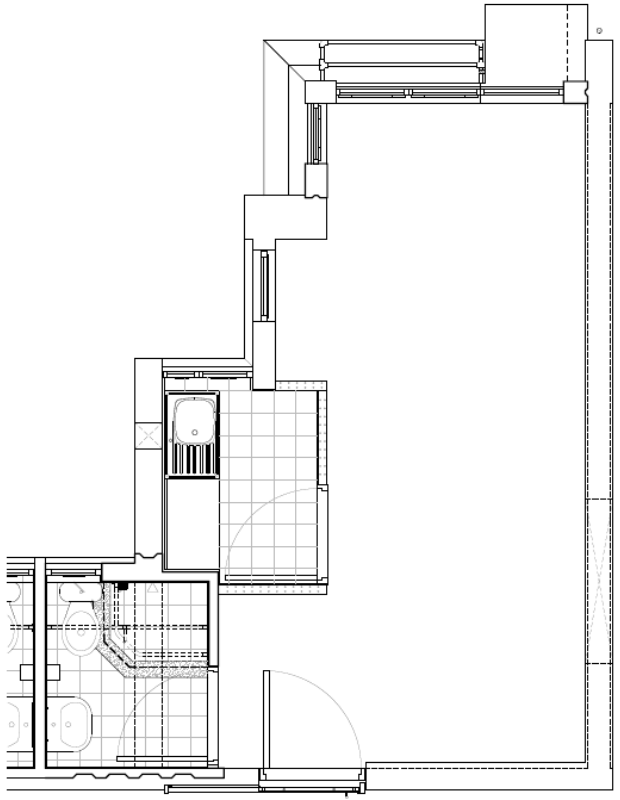
(7) Additional Touch-up Works

- MiC has notable benefits for projects involving substantial finishes and fitting works.
- HA's developments are of no-frills design without sophisticated fittings and finishes.



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(7) Additional Touch-up Works (Cont'd)

- Damage of pre-apply painting within and outside flat.
- Re-apply painting after installation of modules and concreting required.

MiC Pilot Project

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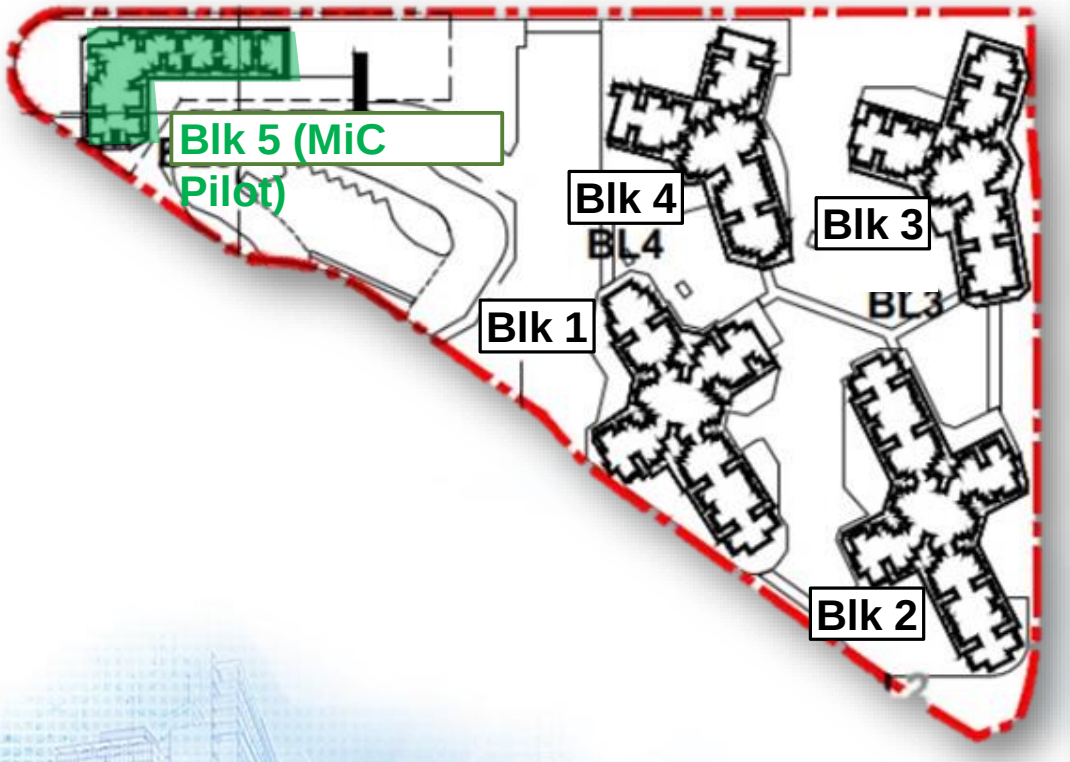
- Domestic Block : 12 storeys w/ 240 flats
- Commencement : 2021
- Completion : 2024



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Thank You

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Statutory Requirements for BS Installations for MiC & Opportunity of BS DfMA for Public Housing Developments

by

Henry Y S CHANG

(Chief Building Services Engineer)

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PART I : Statutory Requirements for BS Installations for MiC

PART II : Opportunity of BS DfMA for Public Housing Developments

PART I
Statutory Requirements for BS Installations for MiC

PNAP APP-161

MiC is a construction method that freestanding volumetric modules (with finishes, fixtures, fittings, etc.) manufactured off-site.

GFA exemption
Electrical conduits and water supply pipes shall be included in the MiC modules while cables, electrical accessories, electrical appliance and town gas pipe are not mandatory.

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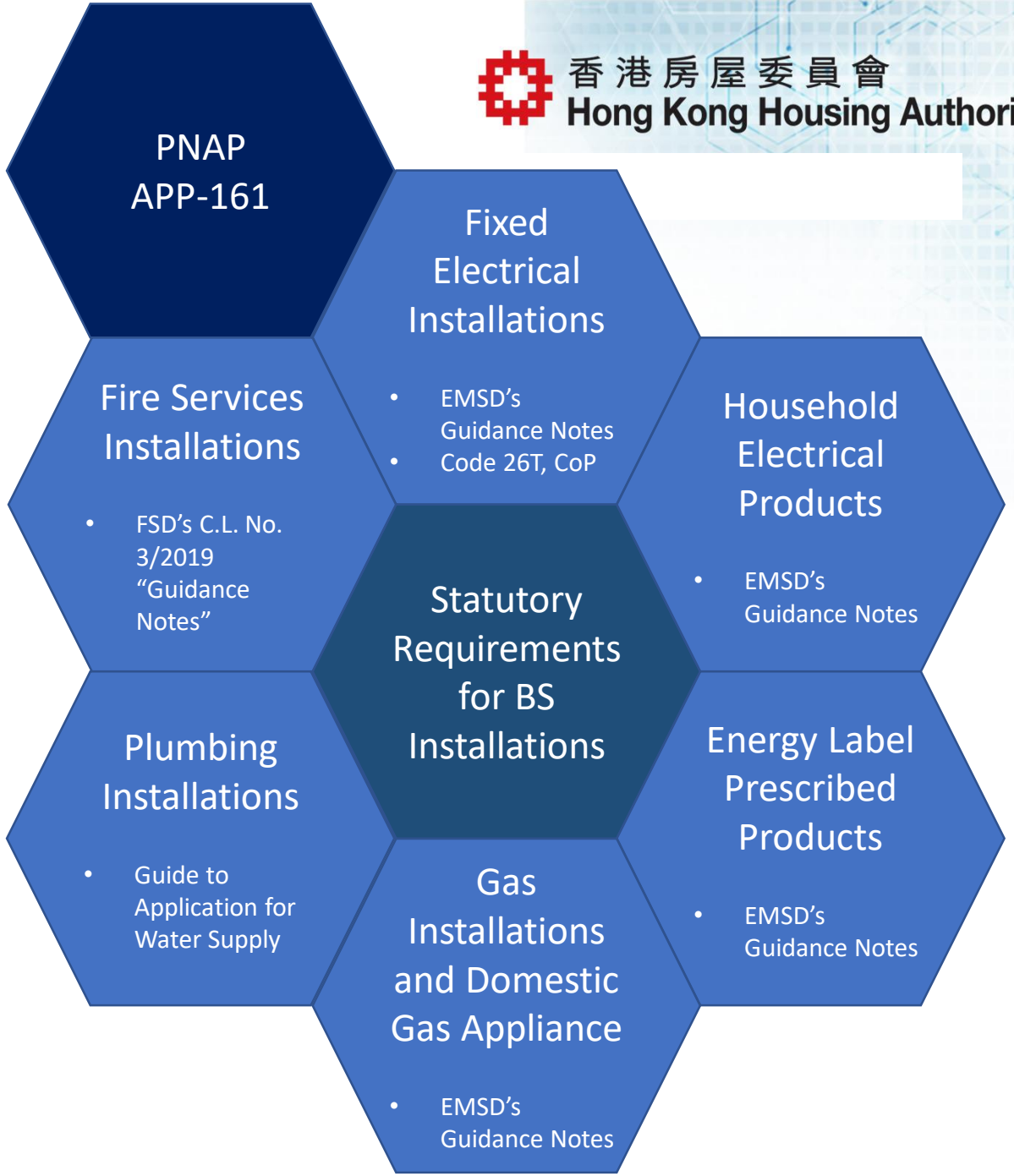
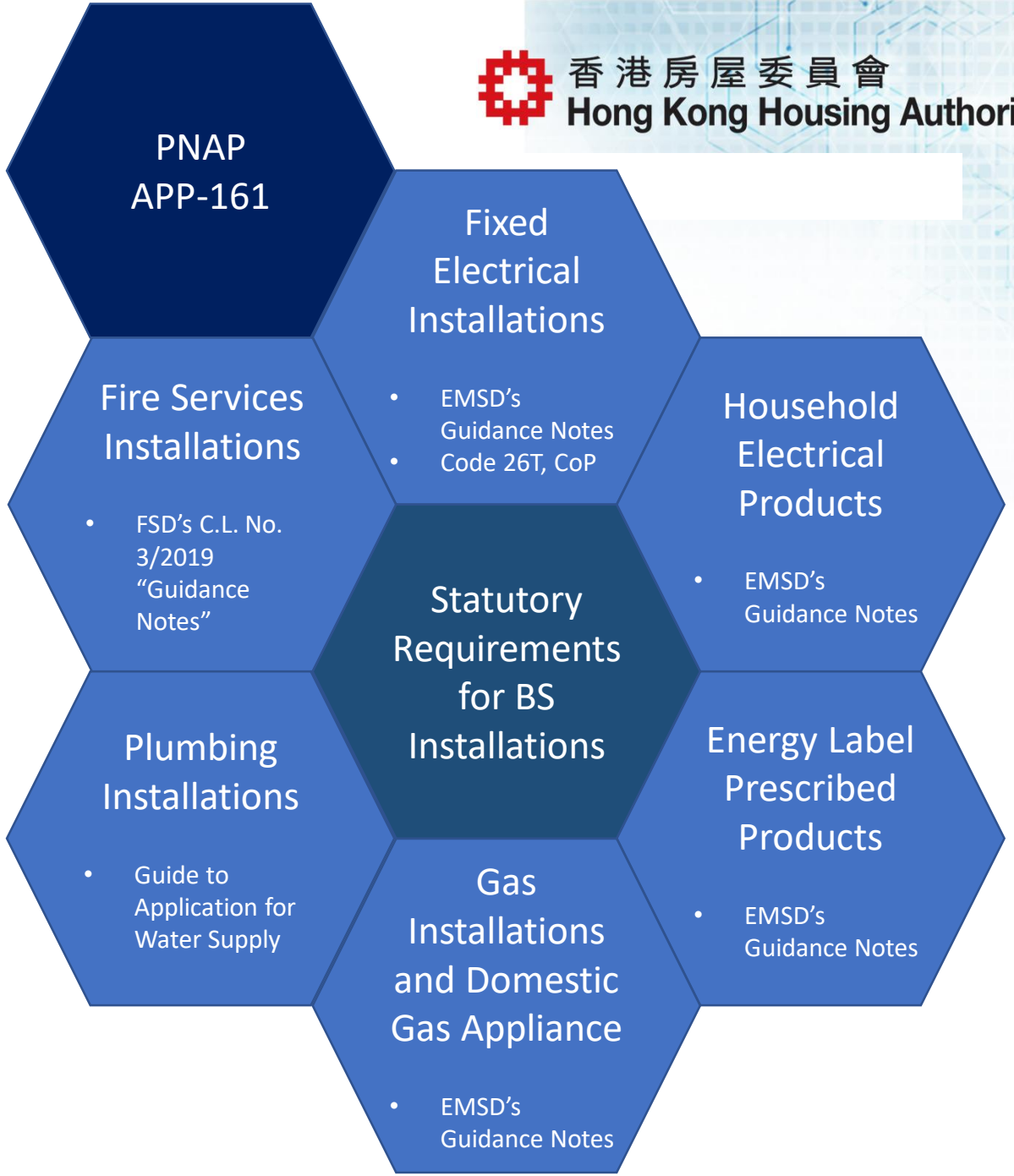


PNAP APP-161

Fixed Electrical Installation

- REC/ REW shall ensure MiC electrical assembly be inspected and tested before delivery
- REC/REW shall ensure suitable materials and good workmanship in MiC electrical assembly
- REC/REW to establish with the factory for a quality control and supervision system
- Scope of works among Contractors properly defined
- Electrical Sub-contractor responsible for completed fixed electrical installations



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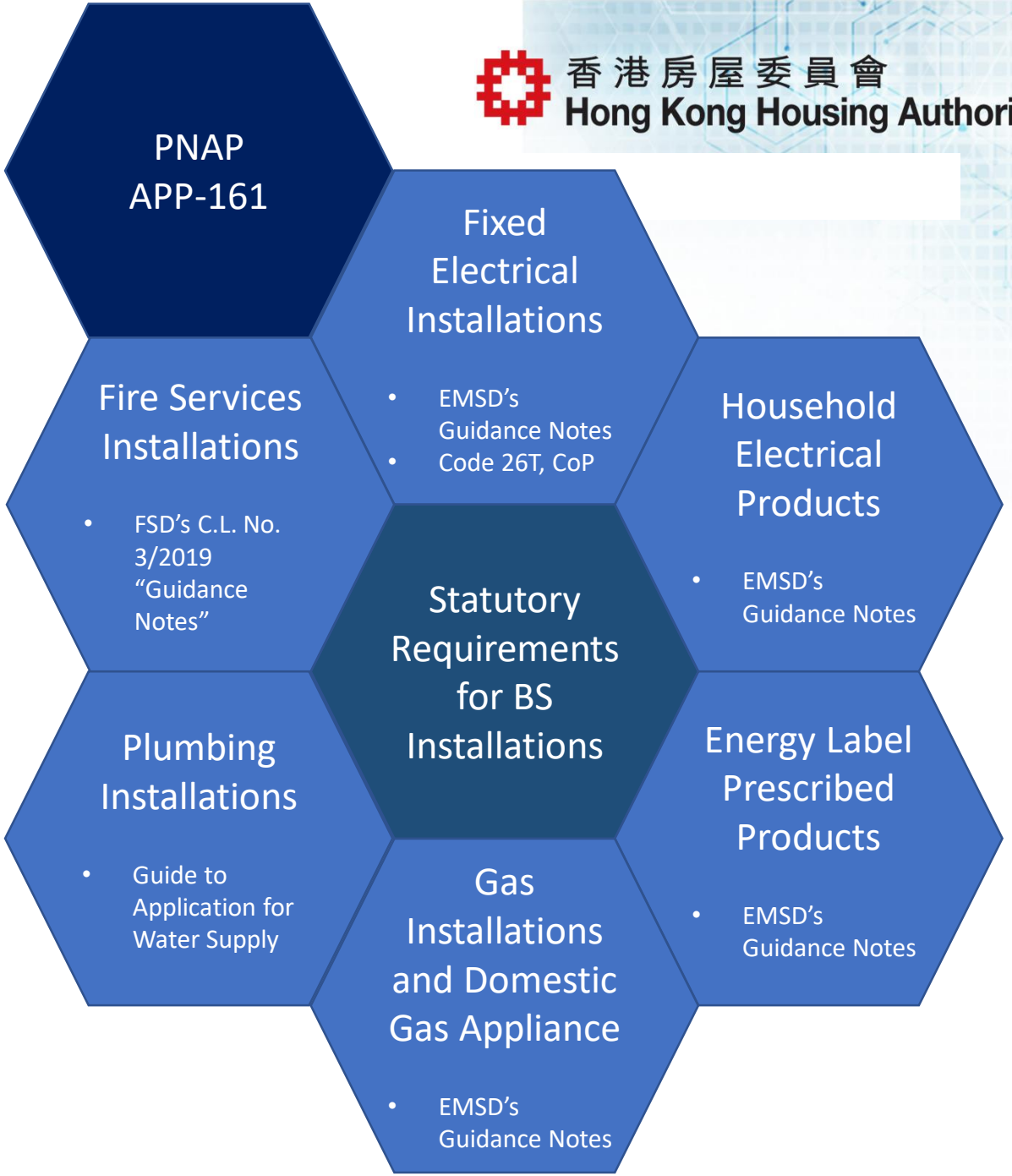
Fixed Electrical Installation

Household Electrical Products

- Electrical Products (Safety) Regulation (Cap. 406G) ("EPSR") under the Electricity Ordinance (Cap. 406)
- Electrical products such as televisions, refrigerators, electric water heaters should be in compliance with the safety requirements of EPSR
- The products should have valid Certificates of Safety Compliance



PNAP APP-161

Fixed Electrical Installation

Household Electrical Products

Energy Label Prescribed Products

- Energy Efficiency (Labelling of Products) Ordinance (Cap. 598)
- Prescribed products includes room air conditioners, refrigerating appliances, compact fluorescent lamps, washing machines, dehumidifiers, televisions, storage type electric water heaters, induction cookers
- all products shall bear an energy label
- products from mainland/ overseas suppliers or Hong Kong Importer are acceptable

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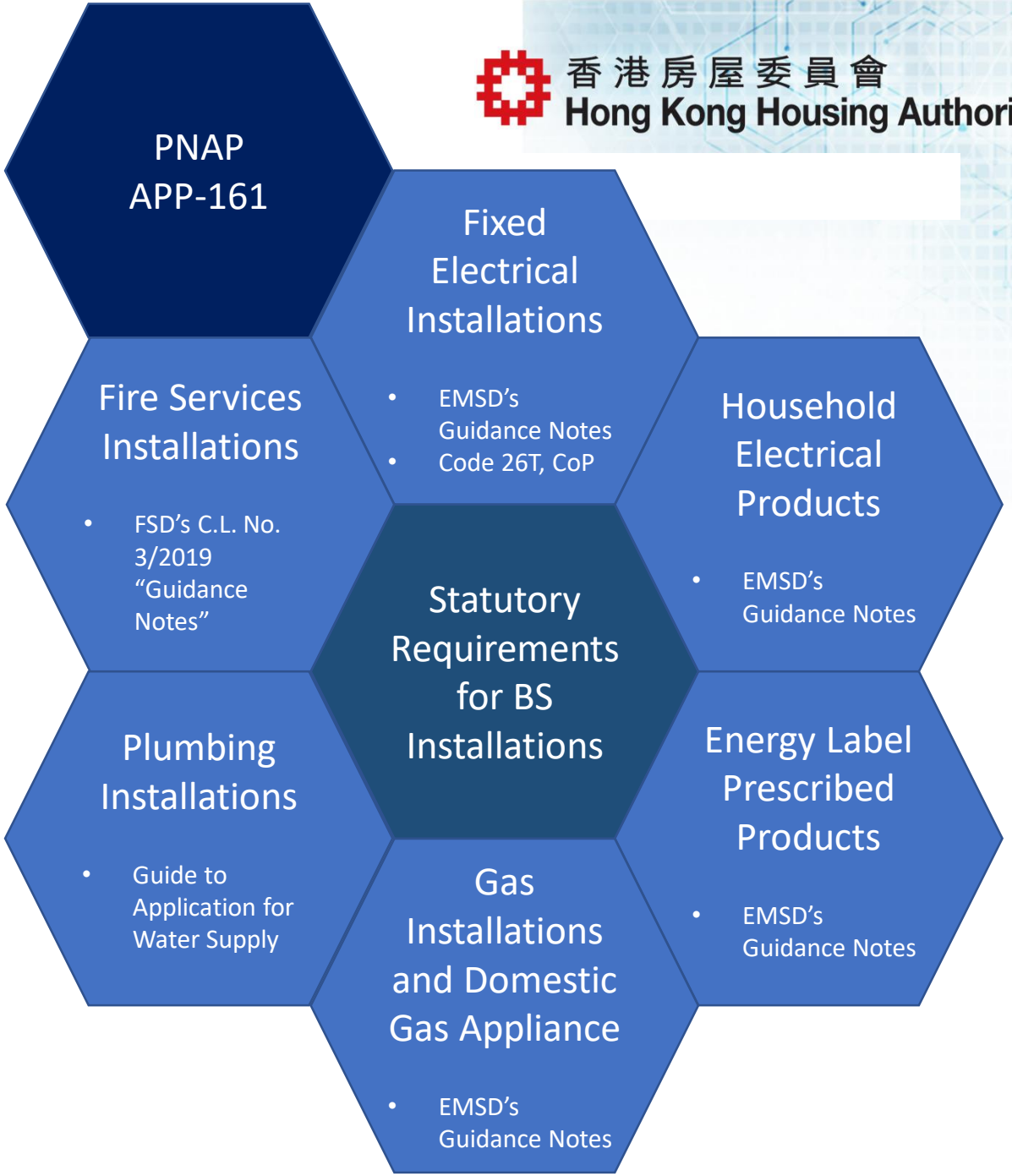

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Fixed Electrical Installation

Household Electrical Products

Energy Label Prescribed P

Gas Installations

- Gas Safety Ordinance (Cap. 51)
- Domestic gas appliances includes cookers, water heaters, clothes dryers shall bear GU mark
- Propose not to preinstall gas pipes
  - extra union joints for linking up pipeworks would pose higher risk of gas leakage
  - risk of dislocation during transportation

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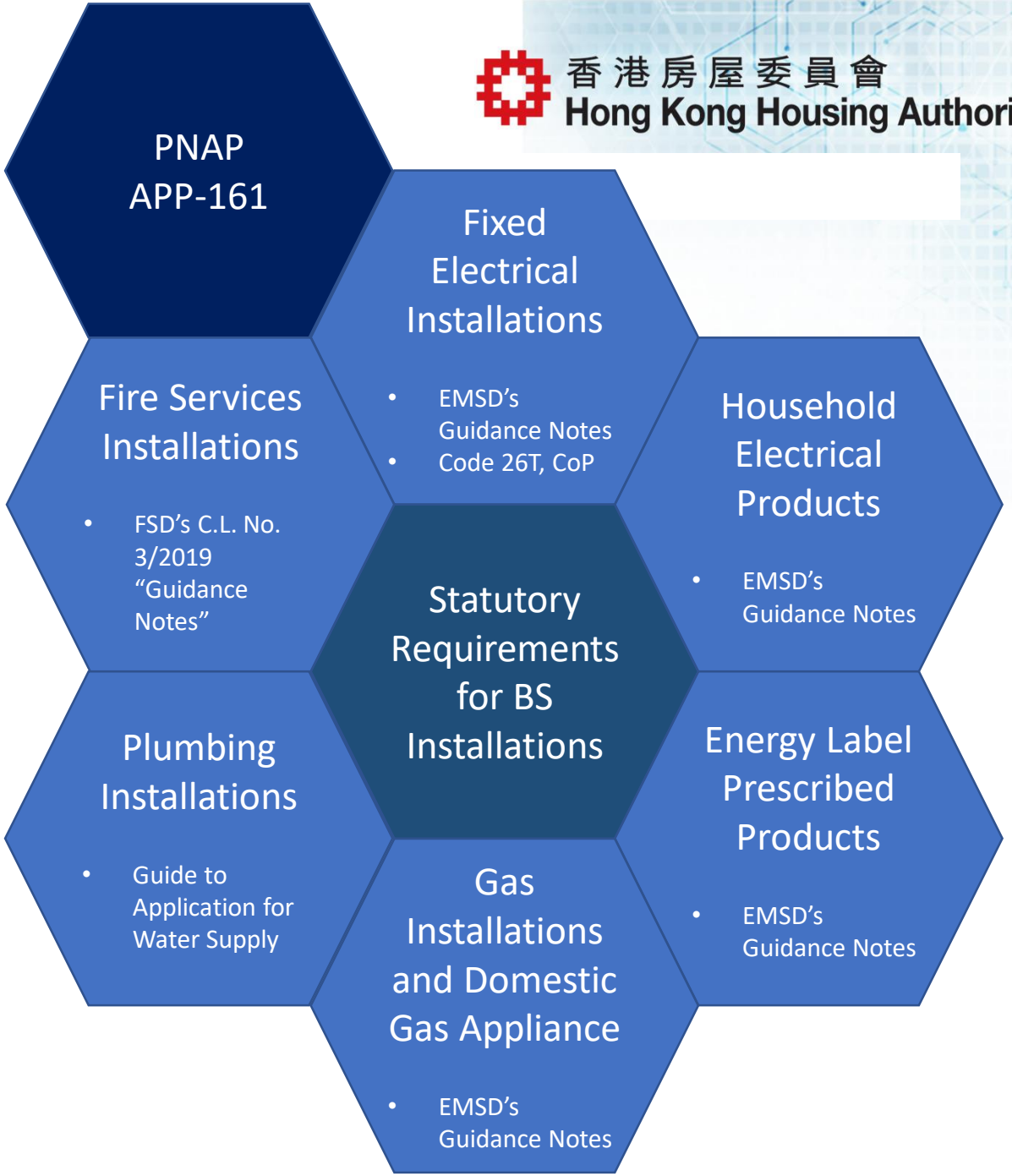

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Fixed Electrical Installation

Household Electrical Products

Energy Label Prescribed P

Gas Installations

Plumbing Installations

- Internal pipeworks pre-installed in MiC factory
- Specify parts of plumbing work constructed off-site
- Submit supervision plan before commencement of works
- Licensed Plumber visits MiC factory at least once a week
- Interim inspection by WSD agent on concealed pipeworks before covered up

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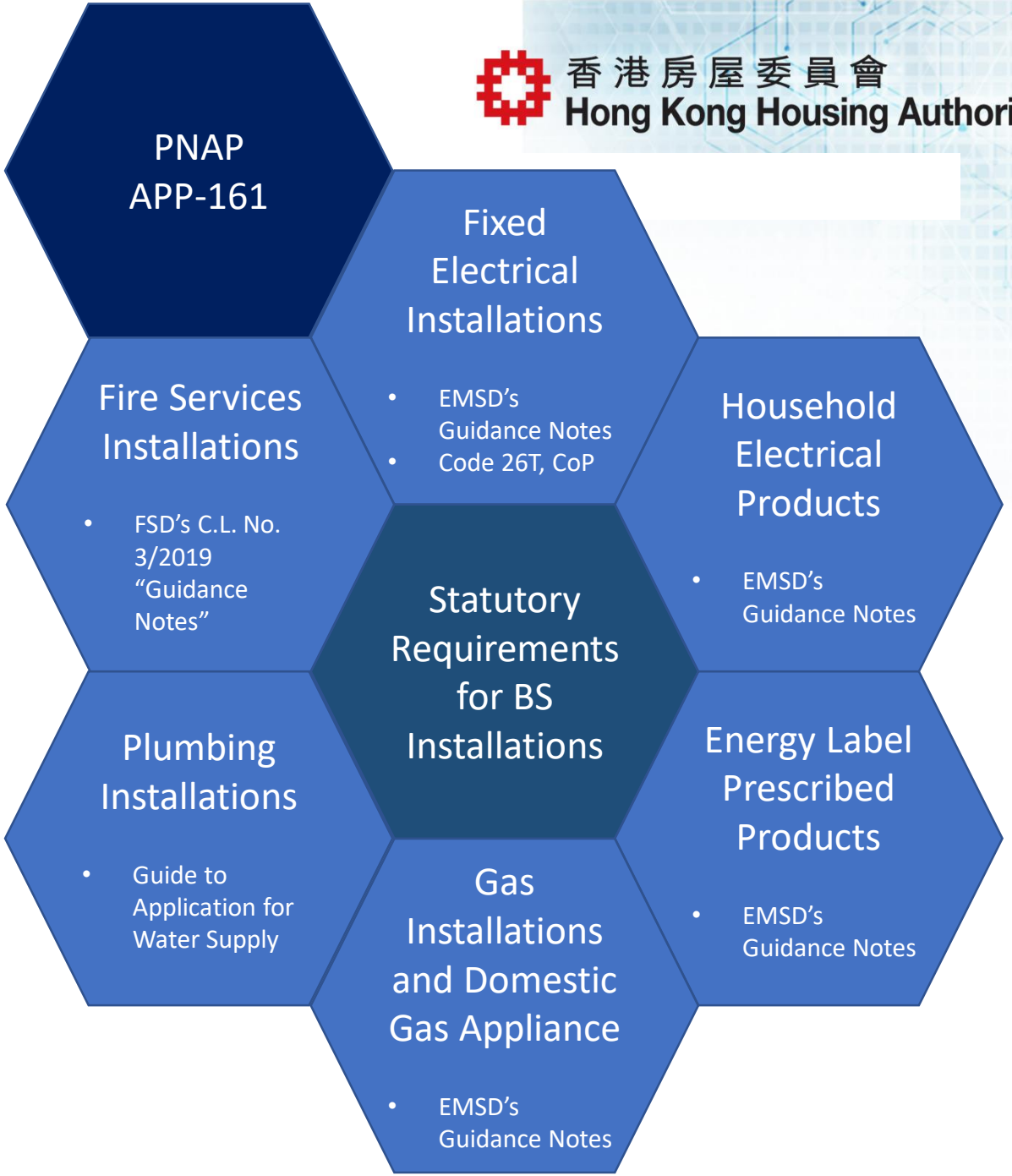

PNAP APP-161

Fixed Electrical Installation

Household Electrical Products

Energy Label Prescribed P

Gas Installations

Plumbing Installations

Fire Services Installations

- to provide access points, inspection pits or accessible recesses for covered up FSI
- To provide flexible pipe joint, FSI cabling facilities between modules (cable joints not allow on fire resistance cables serving FSI)
- All material/equipment with product listing cert. /records /letter or product approval /acceptance letters by FSD
- RFSIC conduct regular supervision in prefabrication process and record in log book for FSD checking

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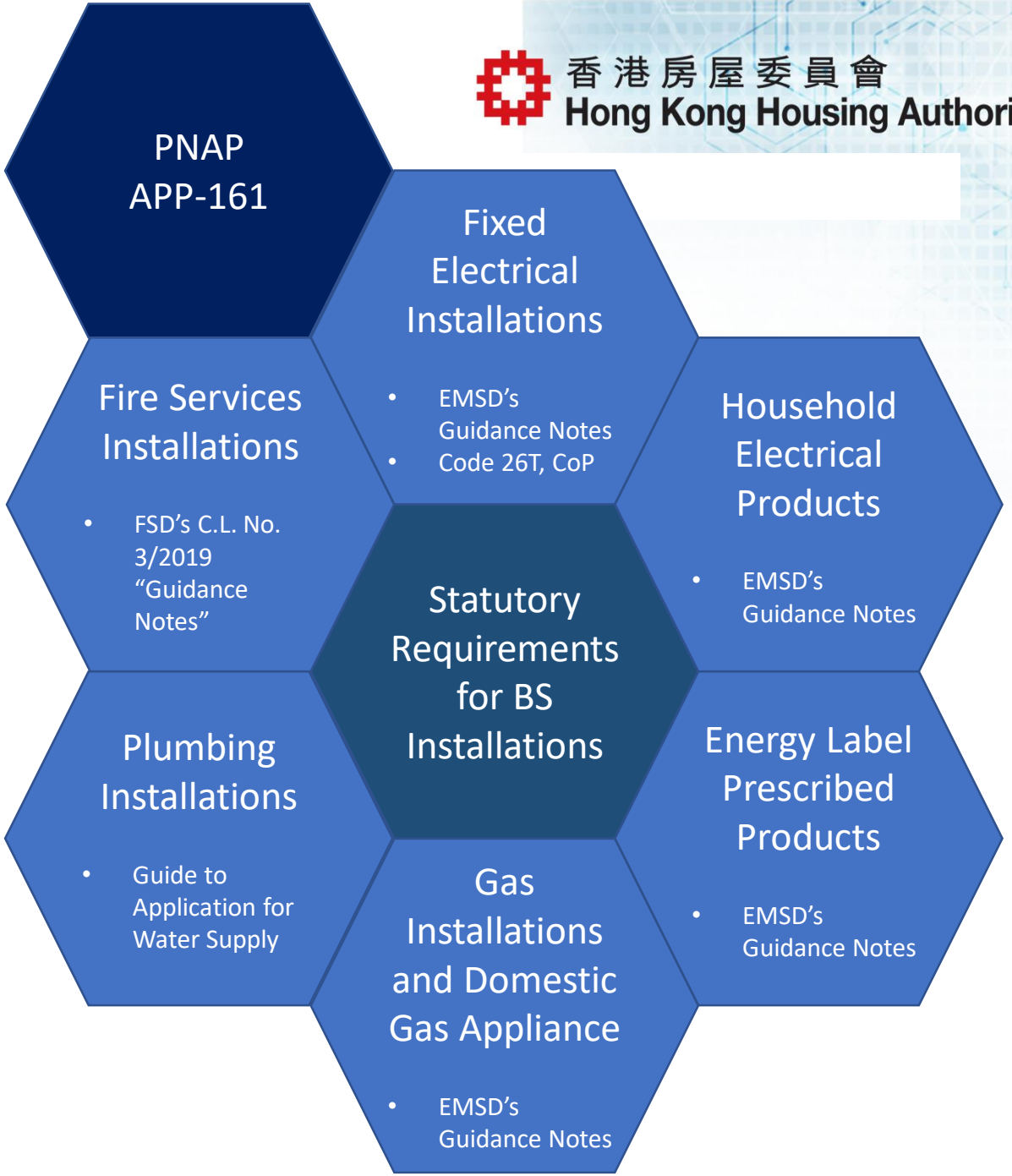


BS Installations in pilot HA MiC taking consideration of the Statutory Requirements

a) MiC modules for typical modular flats are proposed in a pilot HA MiC project.

b) Following BS installations will be pre-installed in the MiC modules –
- Water Pipes
- Electrical conduits, cables and wiring accessories

c) BS sub-contractor is asked to carry out installations in MiC factory

BS Installations in pilot HA MiC taking consideration of the Statutory Requirements (Cont'd)

Brief Procurement of Electrical Contractor in the Pilot Project

a.	**Contract Arrangements** Continuing Nominated Sub-contract arrangement. Entire electrical work, both in factory and on site, by one single NSC (except concealed conduits by MC as currently practicing)
b.	**Special Provisions in Tender** MiC modules fabrication programme and location of potential factories
	Allow ELNSC having adequate time and liberty to work in factory
	Allow storage area, office area, workshop area for ELNSC
	Factory's administration assistance for customs clearing and tax reporting

BS Installations in pilot HA MiC taking consideration of the Statutory Requirements (Cont'd)

Brief Procurement of Electrical Contractor in the Pilot Project

c.	**Supervision and Inspection of Off-site Works** HA will employ PSP for factory inspection of pre-installed electrical works according to the current HA's standard of inspection in in-situ project

PART II
Opportunity of BS DfMA for Public Housing Developments

Contents

Part IIA – MiC

Part IIB – DfMA

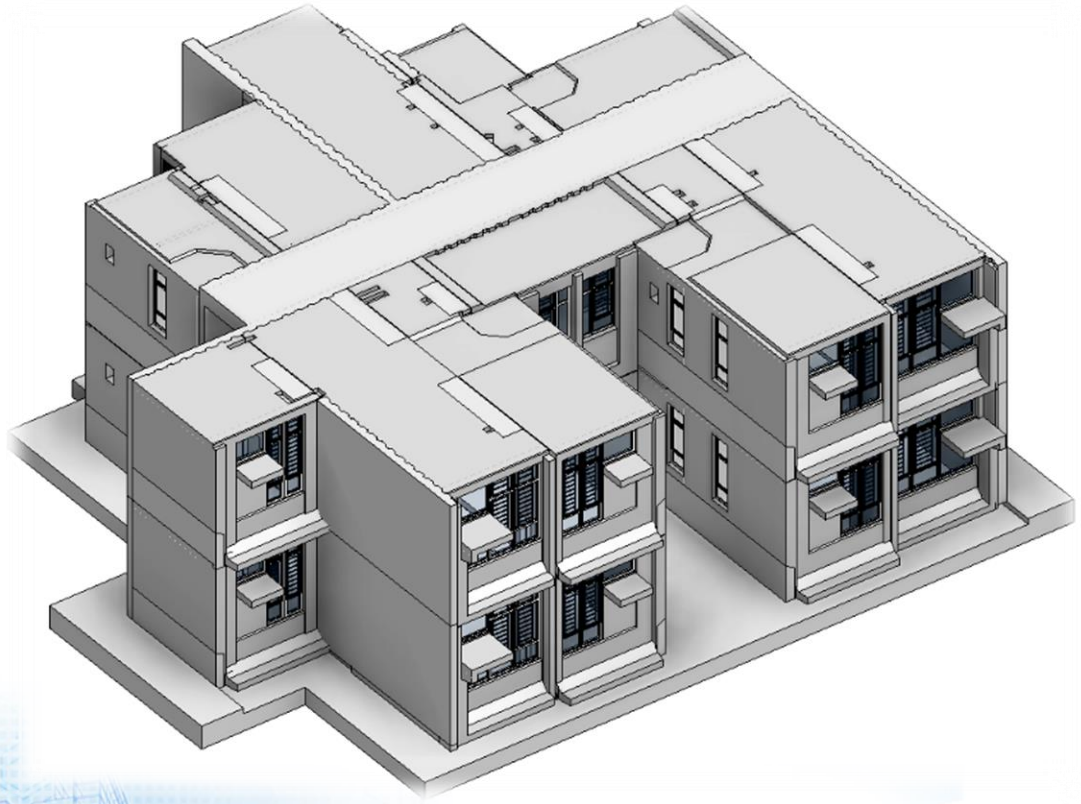
Part IIA - MiC

1. HKHA have identified a suitable MiC pilot project for Public Housing Development which will be commenced soon.

2. A MiC mock-up was completed in December 2020. Some key findings of BS installations were revealed and will be incorporated in the above pilot project.

MiC mock-up

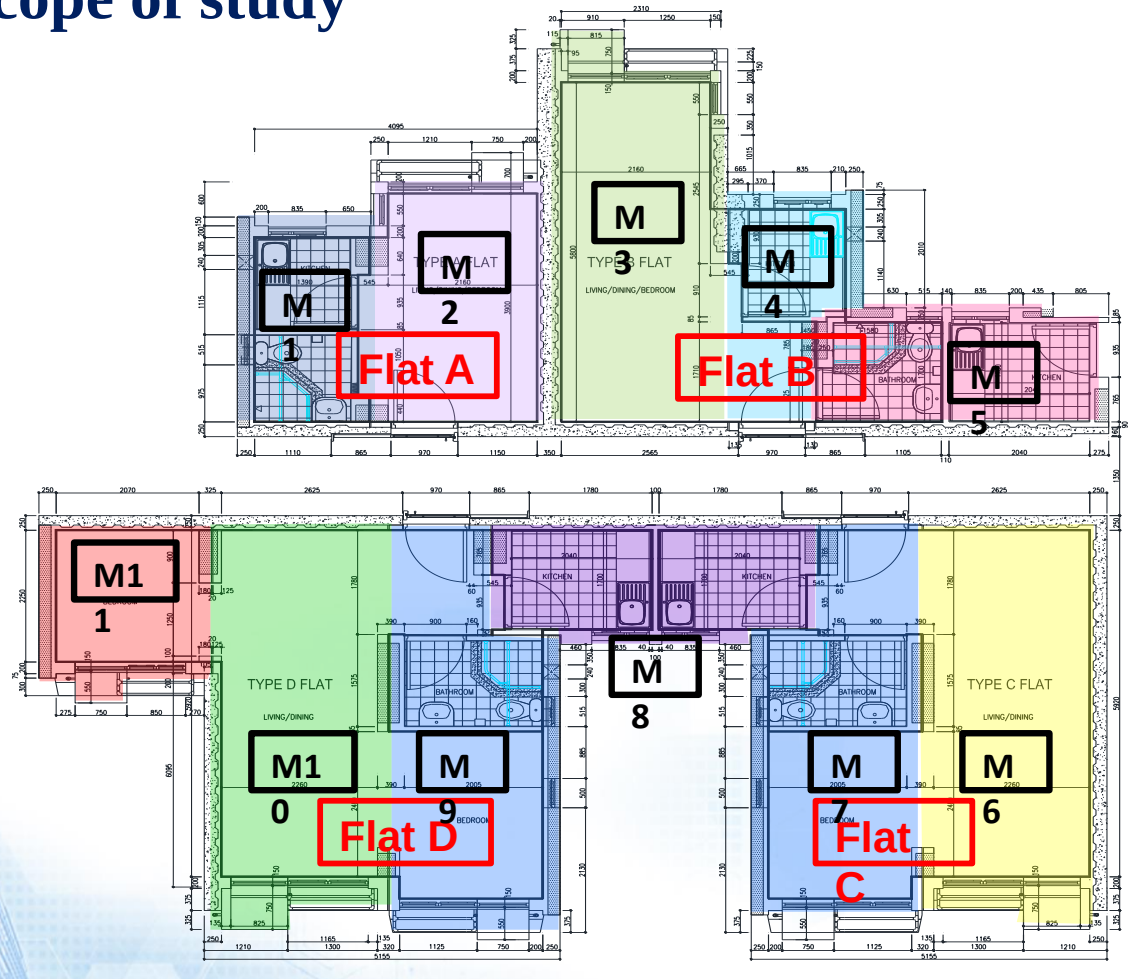
(1) Contract Arrangement



- 2 storeys with 4 Types of Modular Flats, total 8 Flats with 22 modules
- Construction was commenced and completed in Sept 2020 and Dec 2020 respectively.
- Works include the design, fabrication, delivery, installation and construction of mock-up

MiC mock-up

(2) Scope of study



To assess the Arch, SE and BSE details in respect of -

a) Buildability
b) Workmanship
c) Quality Control
d) Joint integrity

MiC mock-up

(3) Scope of Contractor's BS installation Works

- ✓ Conduits & wiring
- ✓ Electrical accessories
- ✓ Consumer units completed with MCB units
- ✓ Adaptable boxes & termination boxes
- ✓ Plumbing services of water supply pipeworks
- × Towngas installation and wiring for telecom and CABD system are **NOT** required.

MiC mock-up

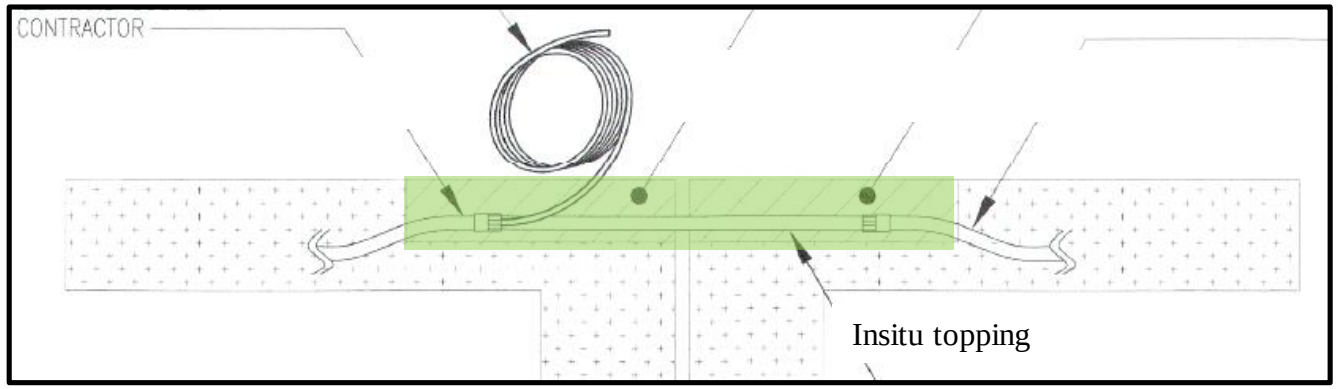
(4) Installation – Building Services (Electrical)

Pre-installed cable

Wiring were pre-installed in modules and THREE wiring connection methods were conducted in the mock-up to investigate their pros and cons.

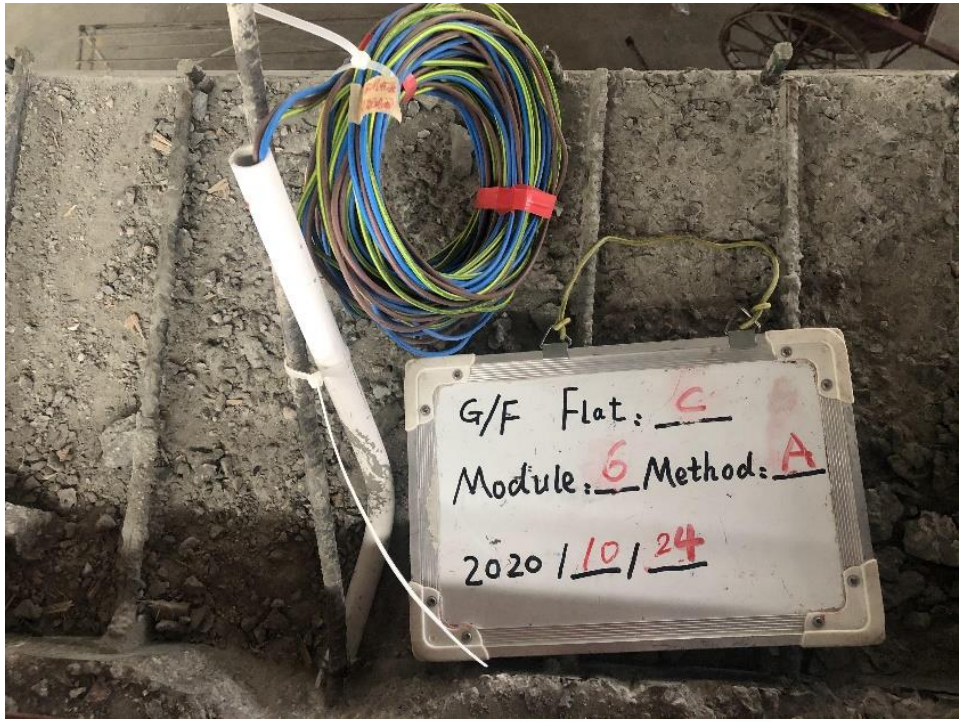
Method A

Cable reserved above the slab at temporary recessed area.



Pros	Cons
1. Less electrical workload in module fabrication stage 2. No adaptable box / termination box required for cable connection	1. Safety concern and more electrical workload during module assembly stage • Workers need to climb up and down for cable and conduit connection before insitu topping between modules 2. Water ingress into conduits 3. Adequate space (min. 1000mm) should be reserved for conduit and cable connection during modules assembly • for conduit and cable connection at the same time

Method A



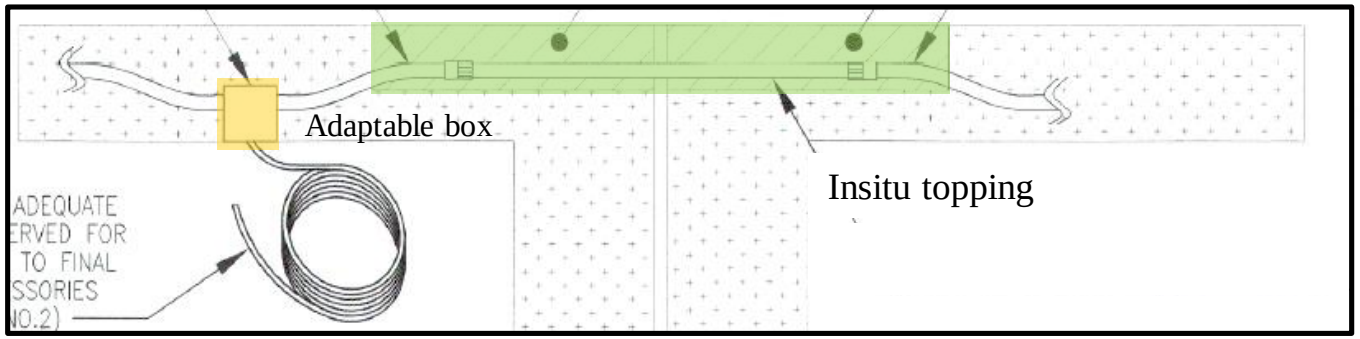
Cable reserved above the slab at temporary recessed area

Protection of reserved cable

Method B

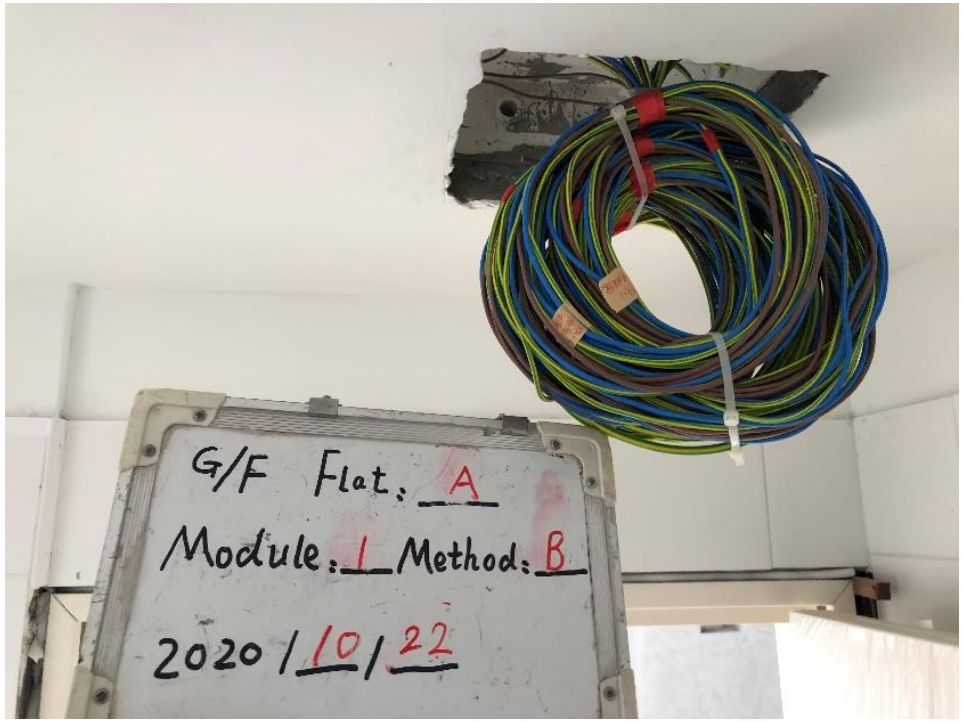
Cable reserved below the slab at adaptable box.

RECOMMENDED

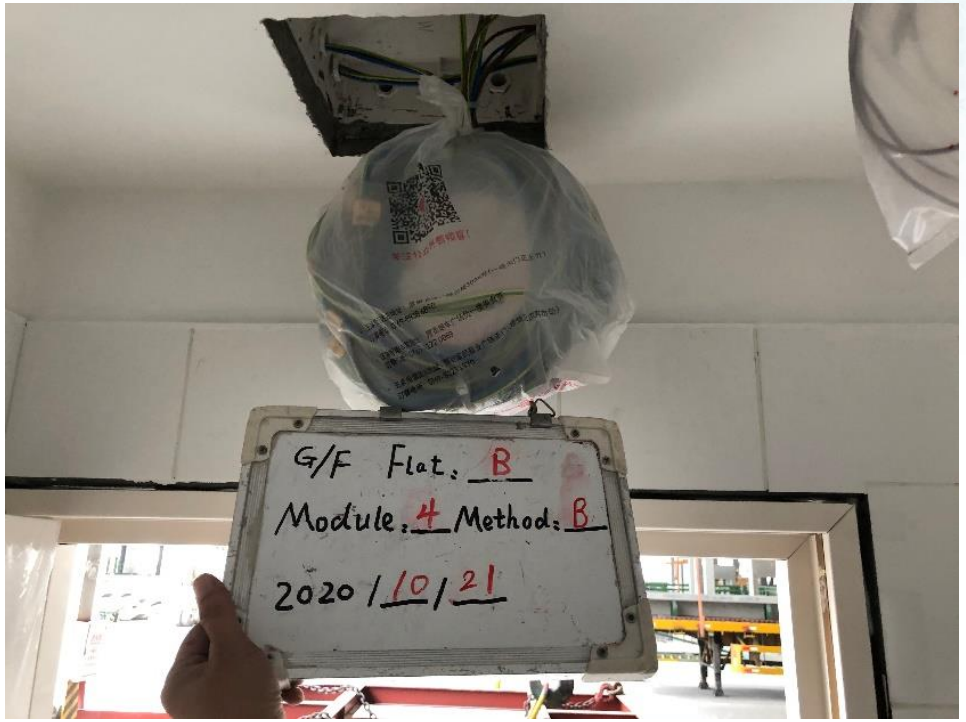


Pros	Cons
1. Less electrical workload in module fabrication stage 2. No risk of water ingress into conduits and damage to cables during transportation and module assembly • Conduit end is plugged off • Cable is reserved indoor 3. Final cable connection work after MiC module assembly and conduit connection is smooth	1. Adequate space (min. 600mm) should be reserved for conduit connection during modules assembly (also apply to Method C) • space between layers of steel bars is congested for conduit connection

Method B



Cable reserved below the slab at adaptable box



Protection of reserved cable

Method B

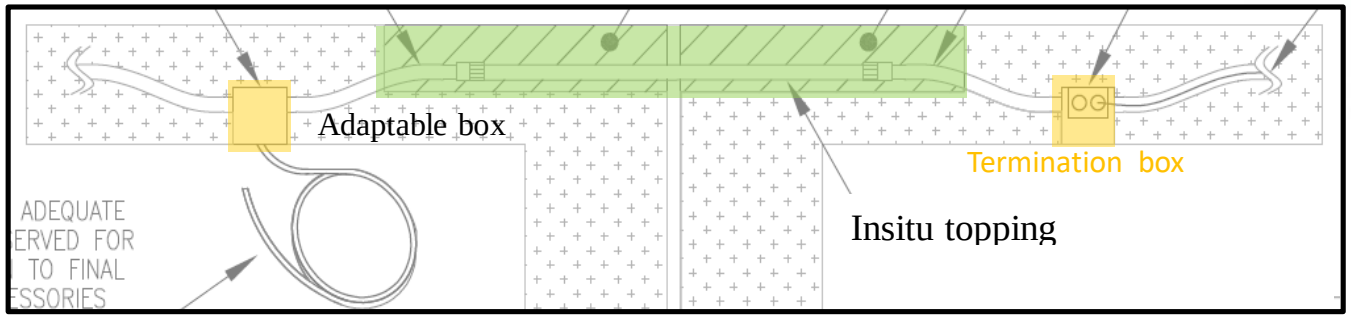
MiC Modules Assembly before conduit connection

MiC Modules Assembly after conduit connection

- Conduits connection on site during MiC Modules Assembly

Method C

Similar to Method B but c/w terminal block in termination box.

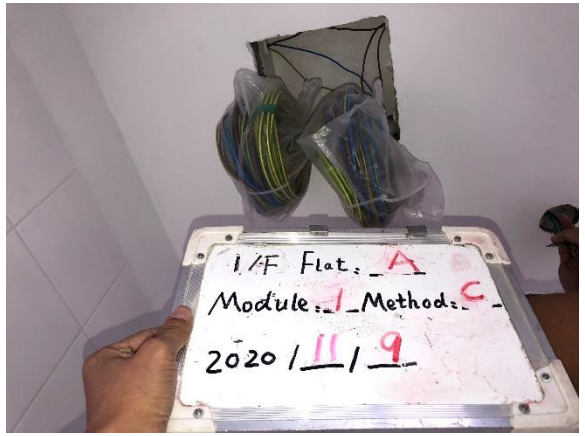


Pros	Cons
1. The highest proportion of MiC application amongst the 3 Methods • over 90% electrical work was completed during module fabrication stage 2. Only short length cable (to termination block) is reserved in adaptable box	1. Space inside termination box is congested 2. Difficult to install/connect cable to terminal block inside termination box • Terminal block may required to be removed and reinstalled after cable connection 3. Bad posture working in a long period of time • Workers require body bending upward for cable connection to terminal block 4. More electrical workload and risk of cable bad contact • require additional cable connection to terminal block 5. More adaptable/termination boxes in ceiling

Method C

Cable reserved below the slab at adaptable box (short length cable to terminal block)

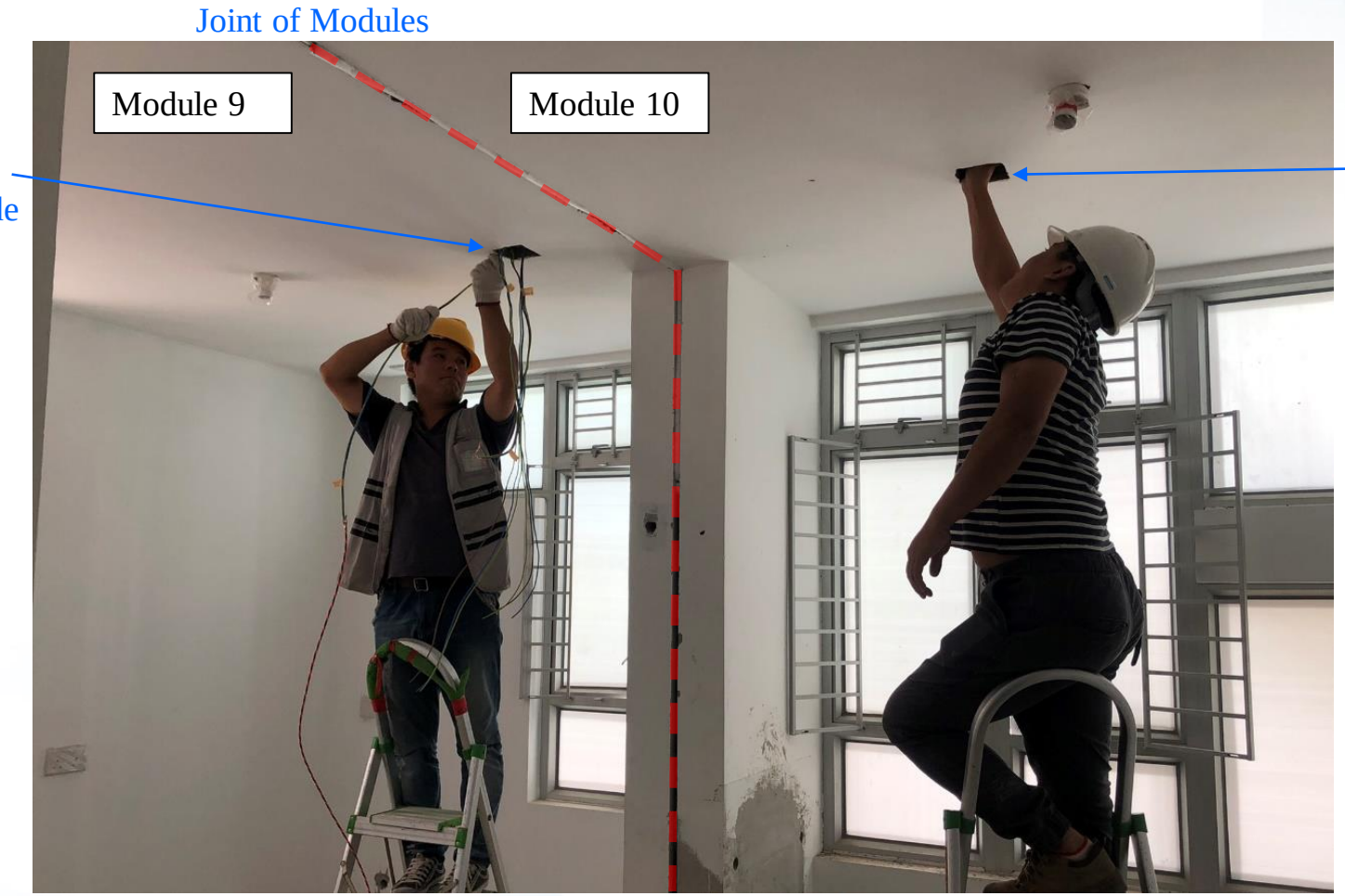
Terminal block in termination box (before cable connection)



Protection of reserved cable

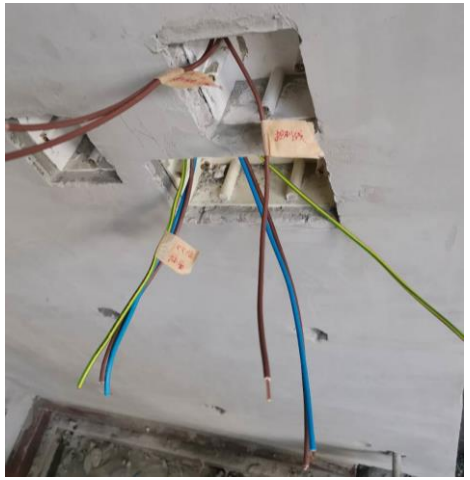
(after cable connection)

Method C

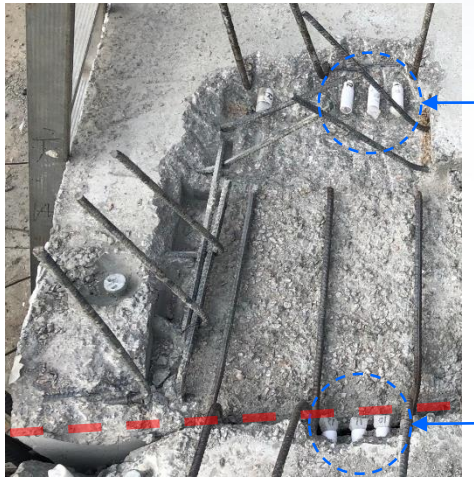


Cable connection on site during MiC Modules Assembly

General



Cables with identification labelling

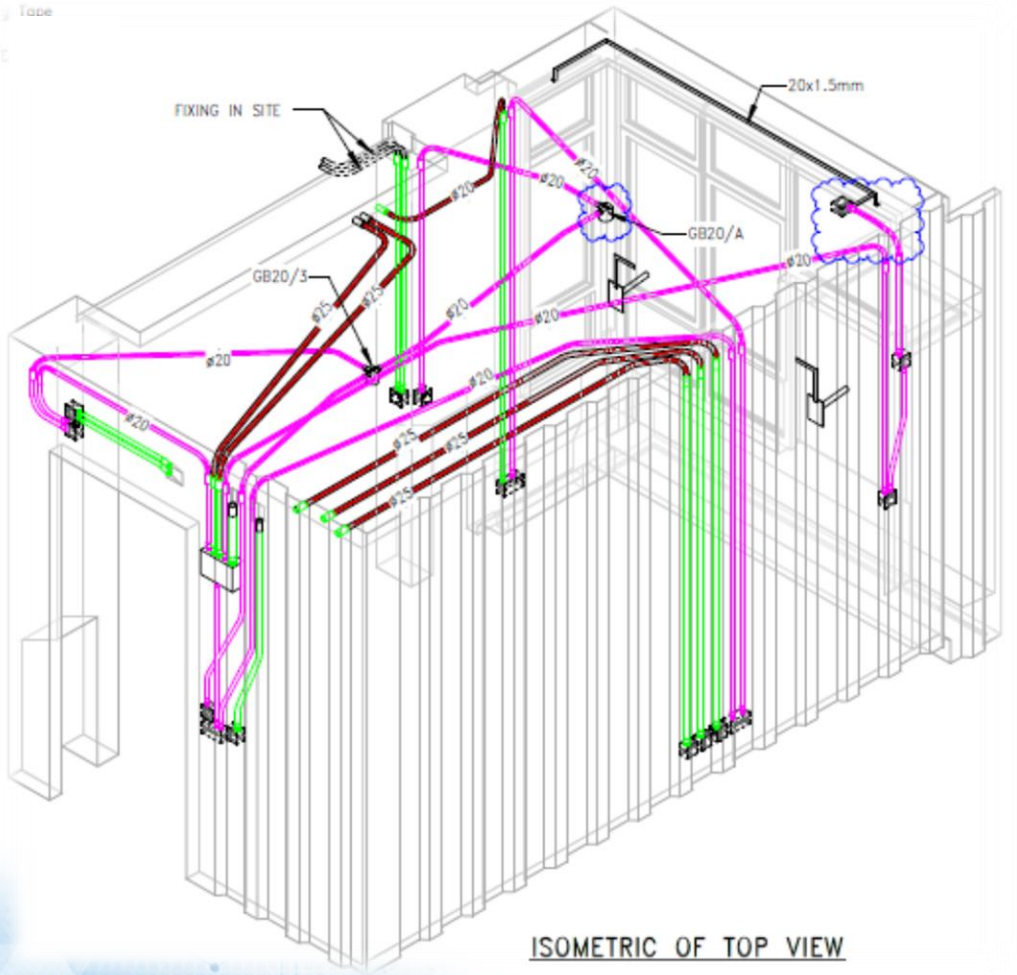


Conduits with identification labelling

Protection of consumer unit

Protection of electrical accessories

Pre-installed electrical conduits and accessories



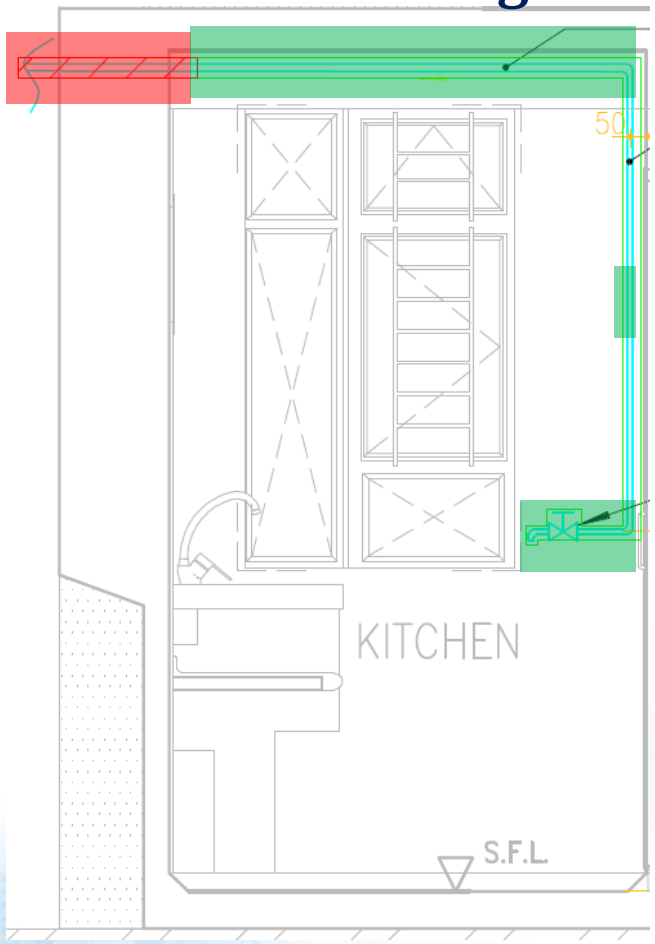
All electrical conduits and accessories (except Telephone points) are pre-installed in modules.

Face plate for:

- Socket outlets
- Lighting switches and points
- TV/FM points
- Connection units (for future A/C units)
- Equipotential bonding
- Door phone unit

MiC mock-up

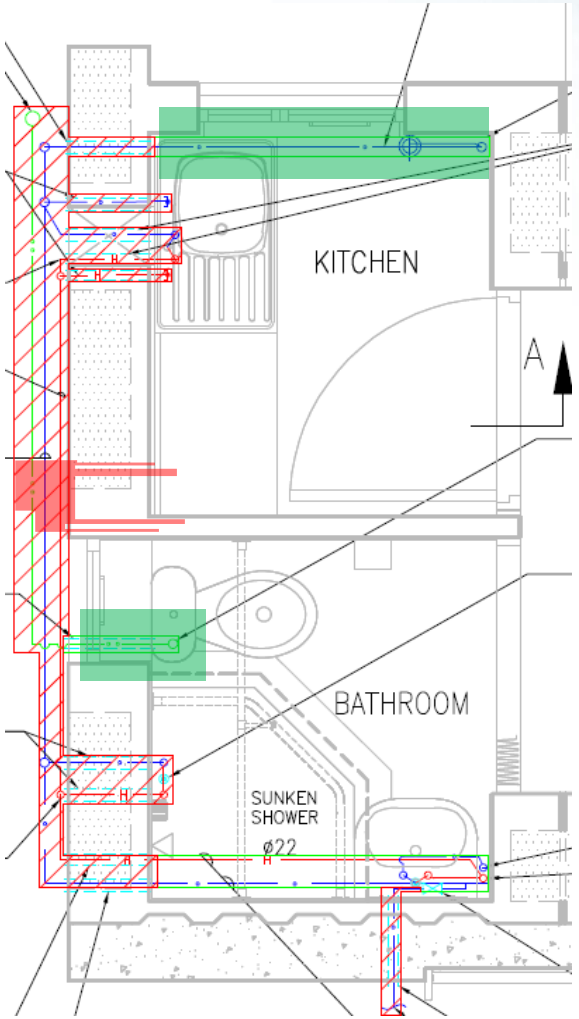
(5) Installation – Building Services (Plumbing)



Plumbing (Kitchen & Bathroom)

Pre-installed: Internal piping with isolating valves inside flat

On-site: All external piping



Findings of Mock-up

1. All electrical wiring and accessories works in MiC modules could be assembled and connected without major issue;

2. Wiring connection with cables reserved below the slab at adaptable boxes between modules (Method B) simplified installation and saved connection time;

3. The back box of pre-installed consumer unit needs to be dismantled and reinstated after wiring work on site at final stage. Installation of consumer unit on site could eliminate abortive work;

4. The whole process, including pre-installation of electrical wiring and accessories in MiC modules, the subsequent assembly and connection works was smooth and manageable;

5. Pre-installation of internal plumbing pipeworks in MiC modules and the subsequent connection works with external pipeworks outside MiC modules could be completed smoothly and manageable without major issue.

Way Forward

The above key findings of BS installation would be incorporated in the coming MiC pilot project in a Public Housing Development to assess the extra benefits of application of MiC in public housing construction comparing with our current mechanized construction.

Part IIB - DfMA

Opportunity of application of prefabricated BS installations in Public Housing is being explored and trial implementation of some DfMA BS installations may be conducted to test the suitability if suitable site is identified –

1. DfMA for Electrical installations;
2. DfMA for FS & Water pump installations;
3. DfMA for ACMV installations;
4. DfMA for preassembled lift machine;

(1) DfMA for Electrical installations

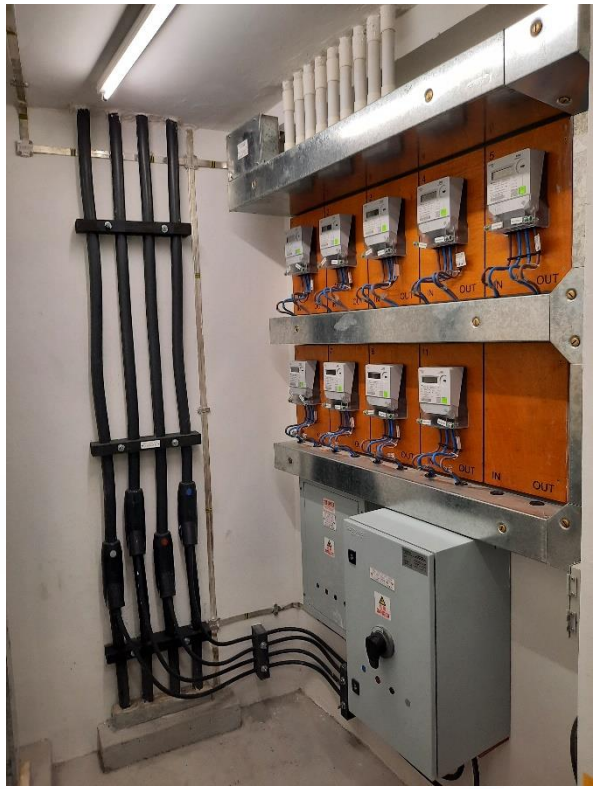
Current DfMA electrical installations

LV Switchboard in Main switchroom

Emergency Generator, Control Cubicle and Switchgear Assembly

(1) DfMA for Electrical installations (Cont'd)

Current DfMA electrical installations (Cont'd)



Prefabricated Cable Riser for domestic floors

Prefabricate Trunking (E-shape)

(1) DfMA for Electrical installations (Cont'd)

Current DfMA electrical installations (Cont'd)

2-stage Lighting Control Box

Concealed Conduits and Equipotential Bonding Accessories in Precast Elements

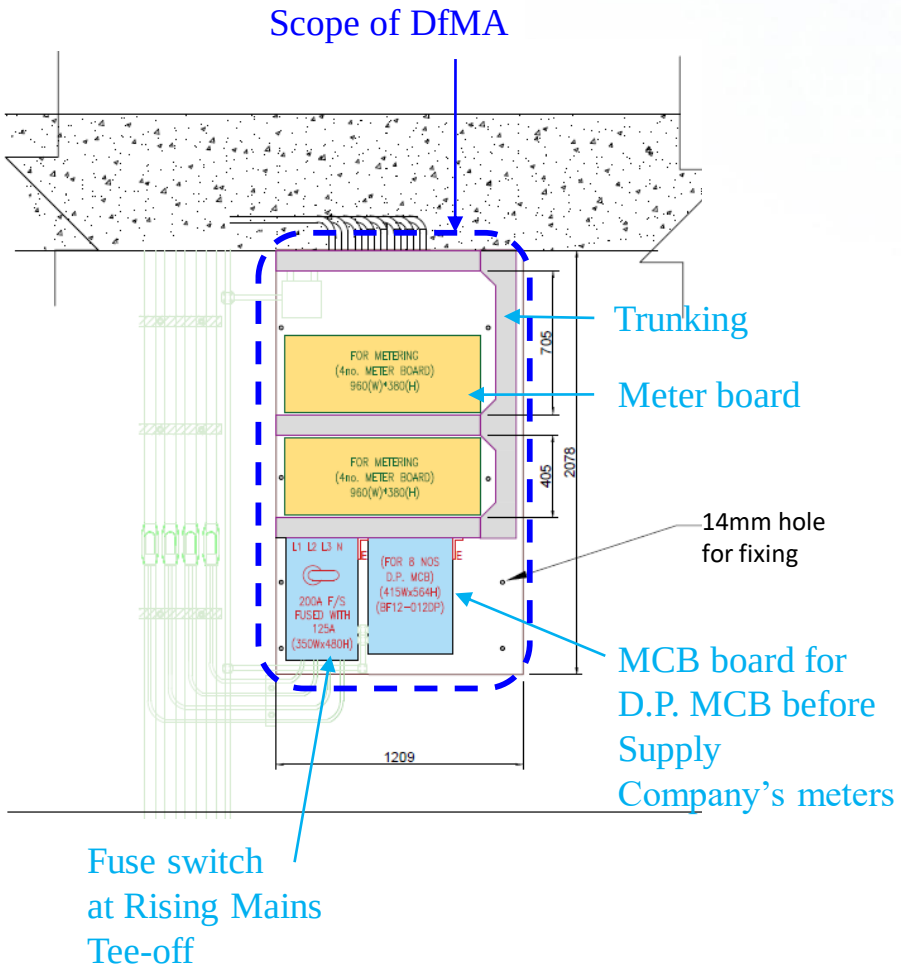
(1) DfMA for Electrical installations (Cont'd)

Potential DfMA electrical installations

At typical floor meter rooms

- Switchgear assembly for domestic flats together with E-shape trunkings, connecting cables and wooden board for supply company's metering equipment

- Switchgear assembly for general lighting, emergency lighting and small power



(1) DfMA for Electrical installations (Cont'd)

Potential DfMA electrical installations (Cont'd)

DfMA electrical installations trial at typical floor meter room

- Process of conventional electrical installation work
- Process of DfMA electrical installation work
- Comparison of installation programme on-site

	Man x hours	Man-hour
Conventional	3 man x 3 hours	9
DfMA	5 man x 10 mins (or 0.167 hours)	0.835
	Time saving per meter room (for 8 flats) :	8

(1) DfMA for Electrical installations (Cont'd)

Potential DfMA electrical installations (Cont'd)

DfMA electrical installations trial at typical floor meter room

- The following benefits were observed in the above DfMA trial exercise / are anticipated in the long run -
  - Enhance construction quality, site safety and working environment for electrical work assembled in factory (off-site)
  - Shorten installation programme on site, hence increase productivity
  - Reduce reliance on local labour
  - Labour cost saving for DfMA mass production in factory

(2) DfMA for FS & Water pump installations

Potential DfMA FS & Water pump installations

At G/F fresh and flushing water pump room

- Prefabricated PRV sets for fresh water supply
- Prefabricated PRV sets for flushing water supply
- Prefabricated fresh water pump sets
- Prefabricated flushing water pump sets

At G/F fire services up-feed pump room and sprinkler pump room

- Prefabricated FS upfeed pump sets
- Prefabricated FS fixed & booster pump sets
- Prefabricated sprinkler pump sets

(2) DfMA for FS & Water pump installations (Cont'd)

Potential DfMA FS & Water pump installations (Cont'd)

At Roof fresh water booster pump room

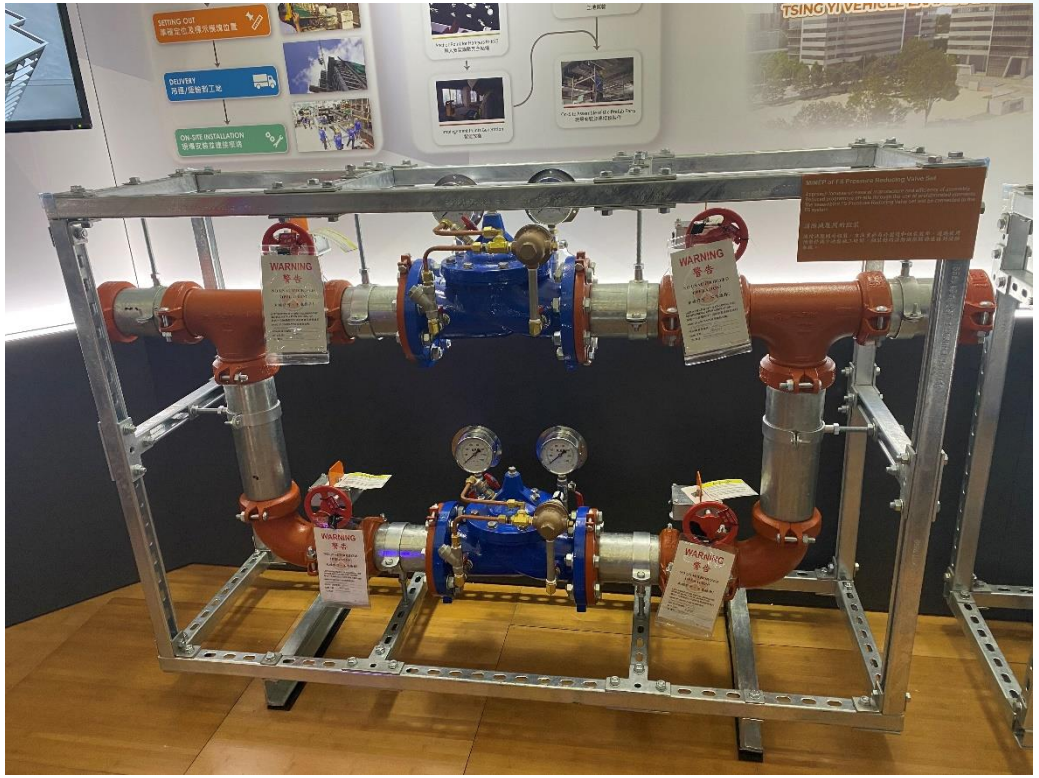
- Prefabricated fresh water booster pump sets

At G/F sprinkler control room

- Prefabricated sprinkler control valve sets

(2) DfMA for FS & Water pump installations (Cont'd)

Prefabricated Water Pump Module*



Prefabricated Pressure Reducing Valve Set Module*

* Photos courtesy of FEMC

(2) DfMA for FS & Water pump installations (Cont'd)

Opportunities

- Alleviating reliance of skilled on-site labour for assembly of water pumps, valves and accessories
- Promoting a safe working environment
- Gaining better quality control and assurance

Challenges

- Making site accessible for the prefabricated modules
- Providing early site access route for delivery of prefabricated modules to water pump room
- Re-scheduling work sequence of water pump installation in building construction programme

(3) DfMA for ACMV installations

Potential DfMA ACMV installations

- Pre-fabricated ductworks
- Pre-fabricated ductwork with exhaust air fan at typical RS&MRR
- Pre-insulated pipes
- Grooved coupling in chilled water pipes
- Pre-fabricated pumpdrop for water pumps
- Cooling tower condensing water pipework system
- Chilled water plant pipework system
- Water pump set and skid with integrated control panel
- Vertical riser module
- Integrated AHU (AHU integrated with LMCP, DDC and valve chamber)
- Modular AHU room

(4) DfMA for preassembled lift machine

- Conventional Practice for Lift Installation
  - Lift system is assembled in lift machine room
  - Assembly work shall be carried out upon completion of lift machine room

- DfMA Opportunity:
  - Preassembly of lift system off-site
  - The preassembled lift system is delivered and installed upon completion of lift machine room
  - Enhance the construction program since assembly work could be carried out regardless of the progress of lift machine room

- Trial project
  - Trial is being conducted in one HA's project. Installation process is in progress.

(4) DfMA for preassembled lift machine (Cont'd)

Photos of trial project in a PRH Development

Preassembled Lift Machine

(4) DfMA for preassembled lift machine (Cont'd)

Photos of trial project in a PRH Development

Delivery of Preassembled Lift Machine to Lift Machine Room

Way Forward

The Housing Authority will continue to explore the opportunity of application of DfMA on BS installations for PHD projects. Trial implementation will be conducted if suitable site is identified in order to examine the above mentioned benefits on BS installations.

香港房屋委員會
Hong Kong Housing Authority

Thank You

香港房屋委員會
Hong Kong Housing Authority

Innovation and Technology (I&T) Adopted in Public Housing Developments

by

Dr. Sherman S L YIP

Chief Architect (Development & Standards)

Hong Kong Housing Authority Industry Forum
Innovative Construction Methods for Public Housing Developments 2021

Contents

1. Introduction
2. Construction Robotics
3. Development and Construction Site Mobile System (DCSMS)
4. Unmanned Aerial Vehicle (UAV) for Inspecting the Building Envelope
5. Reality Capture for Digitalising As-Constructed/Built Works
6. Building Information Modelling (BIM) – Application & Our Roadmap
7. Looking Forward

1. INTRODUCTION

香港房屋委員會
Hong Kong Housing Authority

- *The **Hong Kong Housing Authority (HA)** was established in 1973 under the Housing Ordinance.*
- *The HA **plans, builds, manages** and **maintains** different types of public housing.*

Our Vision

- To provide **affordable** rental housing to low-income families with housing needs, and to help low to middle-income families gain access to subsidised home ownership.

Our Mission

- To provide **affordable quality** housing, management, maintenance and other housing related services to meet the needs of our customers in a proactive and caring manner.
- To provide an **age-friendly** and **barrier-free** estate environment to address the needs of residents of different ages and physical ability.
- To ensure **cost-effective** and **rational** use of public resources in service delivery and allocation of housing assistance in an open and equitable manner.
- To maintain a competent, dedicated and performance-oriented **TEAM**.

Hong Kong Housing Authority Industry Forum
Innovative Construction Methods for Public Housing Developments 2021

HOW TO BUILD Smarter?

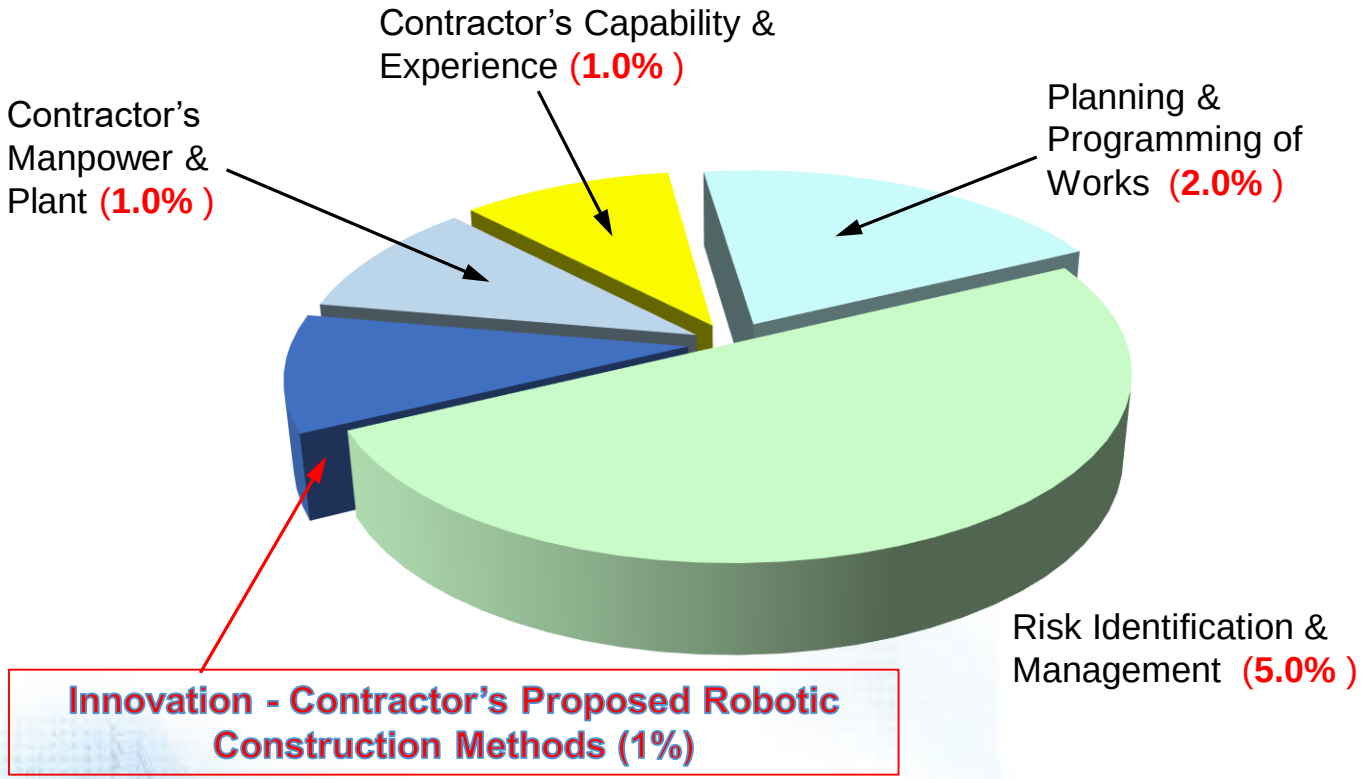
2. Construction Robotics

2. CONSTRUCTION ROBOTICS

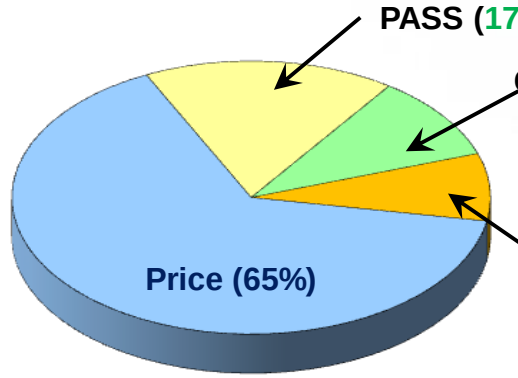
Procurement Strategy for Innovation & Technology

香港房屋委員會
Hong Kong Housing Authority

Proposed Technical Score - Total 10%



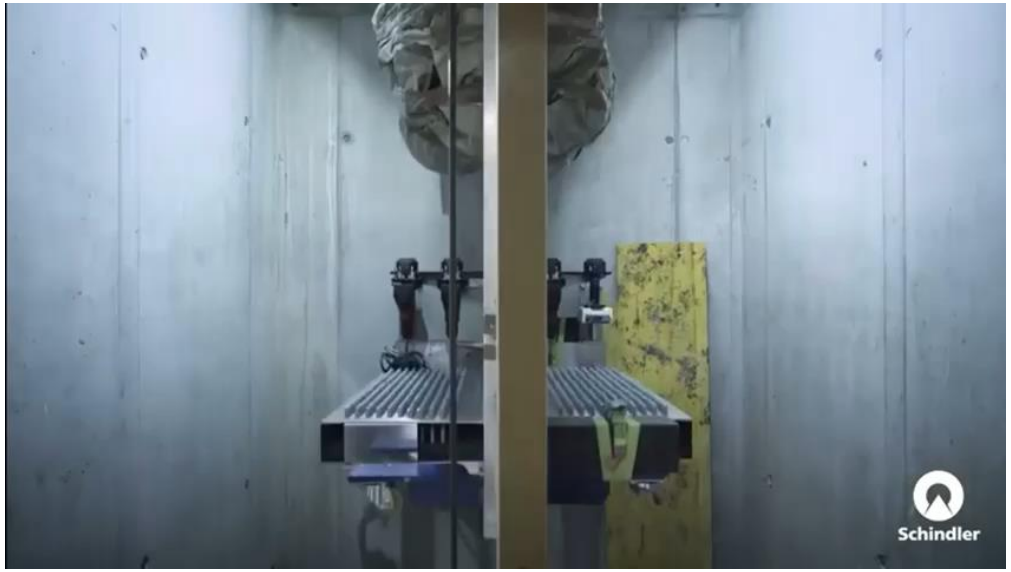
Two Envelope Tendering System for "Complex" Building Contract – 65 : 25 : 10

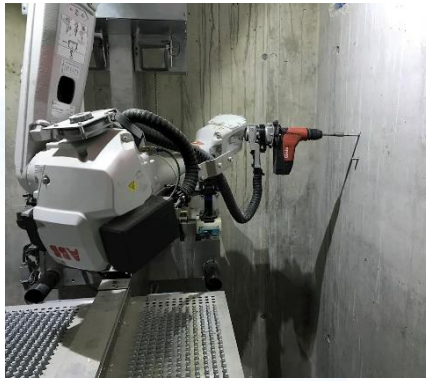


Corporate Score (8%)
- Serious Accident (2%)
- Convictions (3%)
- Wage Monitoring (3%)

Technical Proposal(10%)
- Contractor's capability and experience (1.5%)
- Contractor's manpower and plant (1.5%)
- Planning and programming of works (2%)
- Risk identification and management (5%)

Construction Robotics Examples in Public Housing Developments





Lift Car Brackets Installation at Lift Well

Trial at Queen's Hill Public Housing Developments

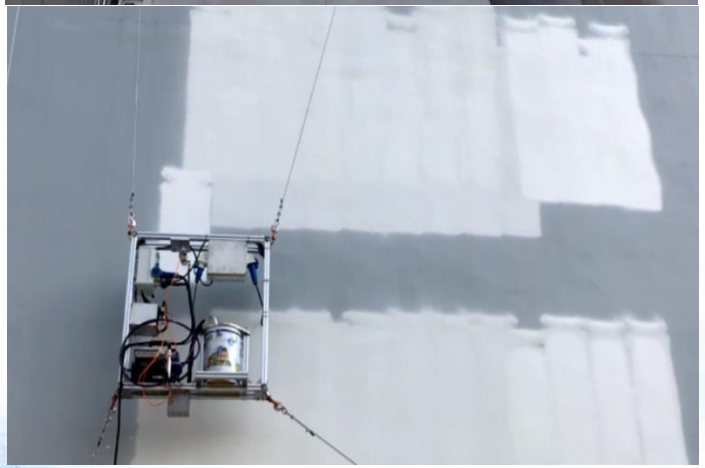
Source: www.schindler.com (Above)

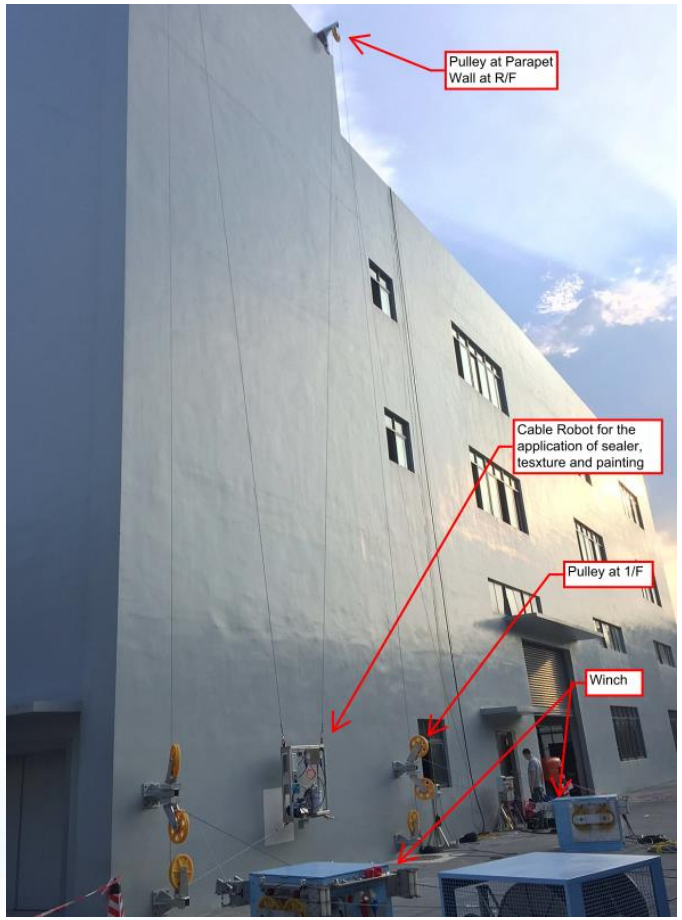
Water Tightness Test at Bathroom

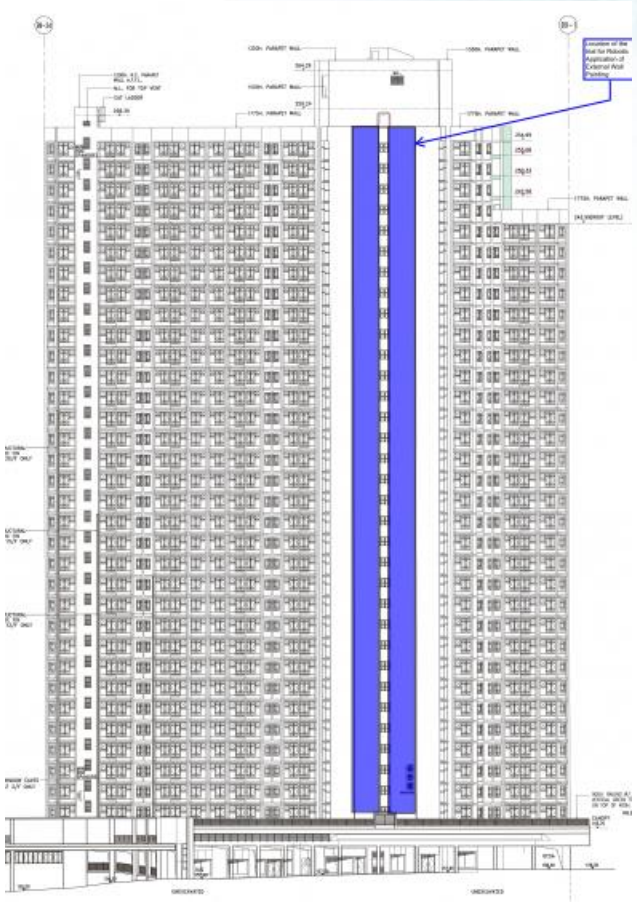
at Fo Tan Public Housing Developments

Construction Robotics Examples in Public Housing Developments

香港房屋委員會
Hong Kong Housing Authority







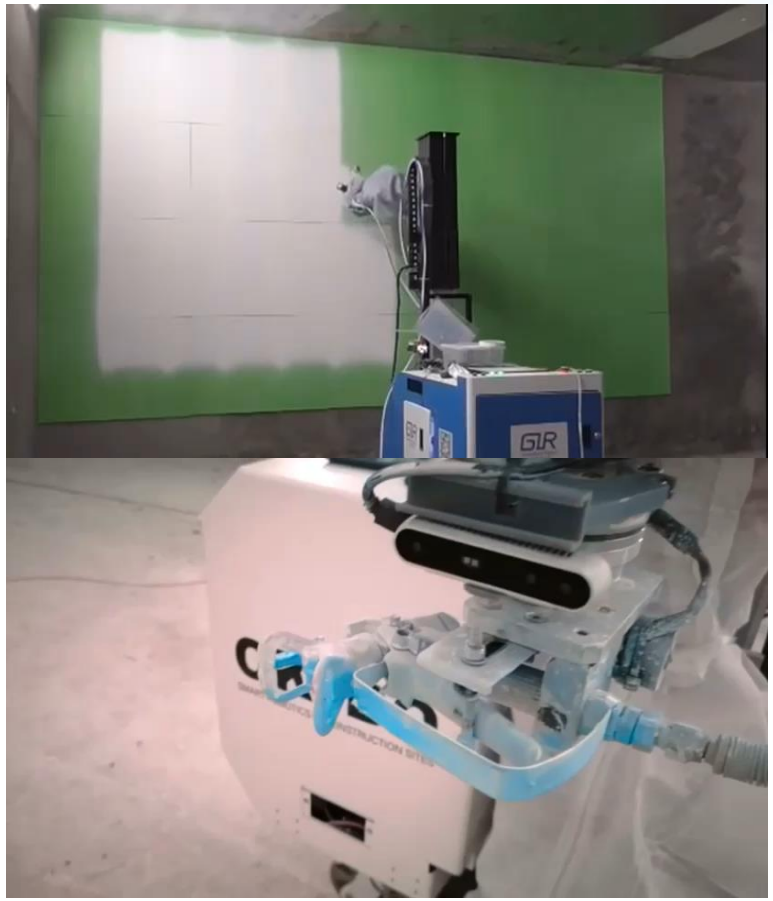
External Wall Painting

Trial at Anderson Road Public Housing Developments (Left)

Potential Applications of Construction Robotics in Public Housing Developments

Floor Finishing

Source: www.fcl.ethz.ch (Above)



Internal Wall Painting

Source: www.turingcat.com (Above)
https://www.youtube.com/watch?v=hm9ZSN37jVM (Below)

3. Development and Construction Site Mobile System (DCSMS)

香港房屋委員會
Hong Kong Housing Authority

DCSMS – Background

DCSMS

Development and Construction Site Mobile System

發展及建築
工地流動系統

香港房屋委員會
Hong Kong Housing Authority

DCSMS – Our Roadmap

香港房屋委員會
Hong Kong Housing Authority

- Mobile-enabled common platform for communication, streamline workflow and improve productivity and traceability in site inspection

Roll-out in	Roll-out from	Roll-out from	Roll-out from
Jan 2016	**Aug 2018 ~ Sep 2019**	**Jun 2020 ~ Mid 2021**	**Aug-2022**
PHASE 1	**PHASE 2**	**PHASE 3**	**PHASE 4**

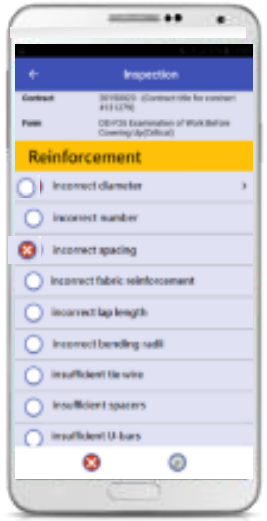
DCSMS – A Centralized Data Processing & Storage System

香港房屋委員會
Hong Kong Housing Authority

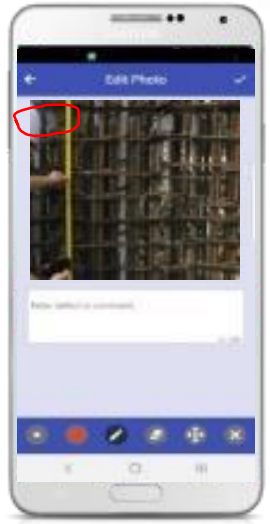
The Workflow with DCSMS

Request for Inspection to Site Staff

Site Work Inspection



Site measurement/ record to the Apps



Site record supplemented with site photos

Site record reflected with mark up on drawings

3. DEVELOPMENT & CONSTRUCTION SITE MOBILE SYSTEM (DCSMS)

DCSMS – A Swift Generation of Management Report

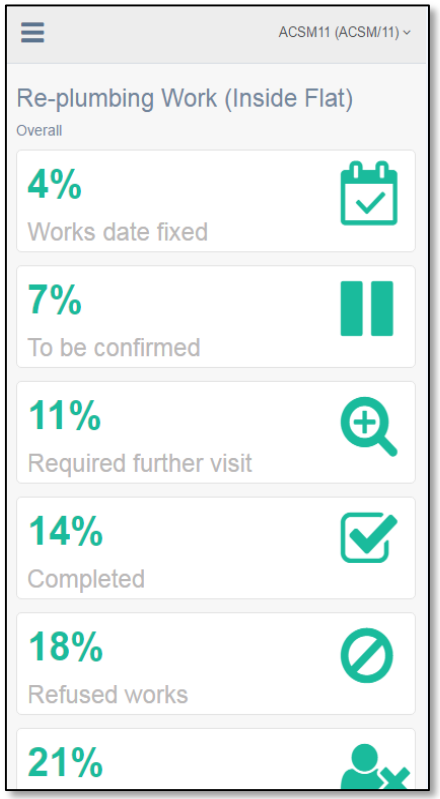
香港房屋委員會
Hong Kong Housing Authority

Replumbing Works:

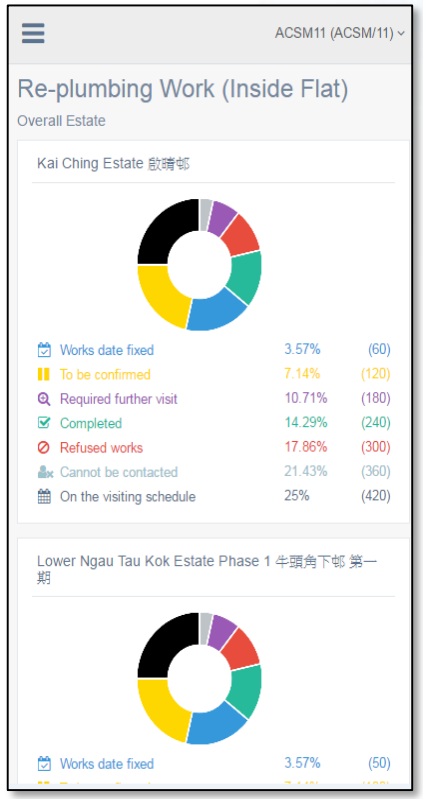
- Quick Access by Senior Management to monitor site progress
- Dashboard Page with numerical data visualized into graphical data

Further Development of DCSMS:

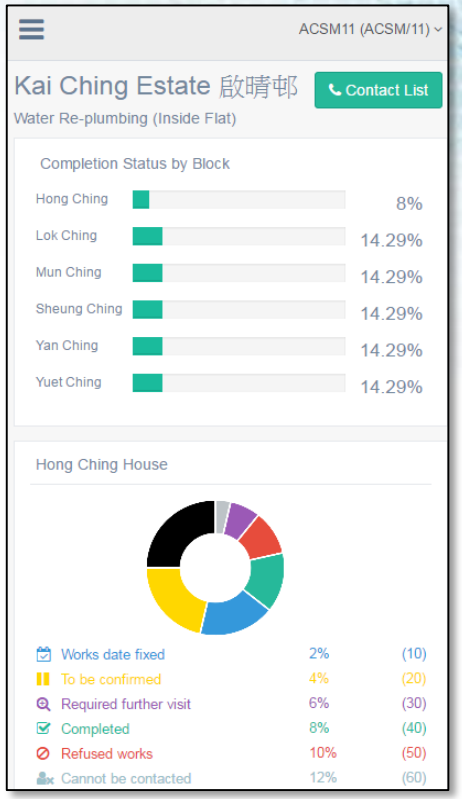
- Site Inspection Progress Dashboard made available to Project Teams for other inspections such as foundation works and flat-to-flat final inspection stage.
- To expand the scope of the DCSMS (from building + building services + structural works to foundation work + building & building services at final inspection stage)
- To Integrate with Apps developed by contractors and other HA's systems



Overview of the work progress



Graphical analysis of the work progress to facilitate monitoring & management



Completion status per each domestic block

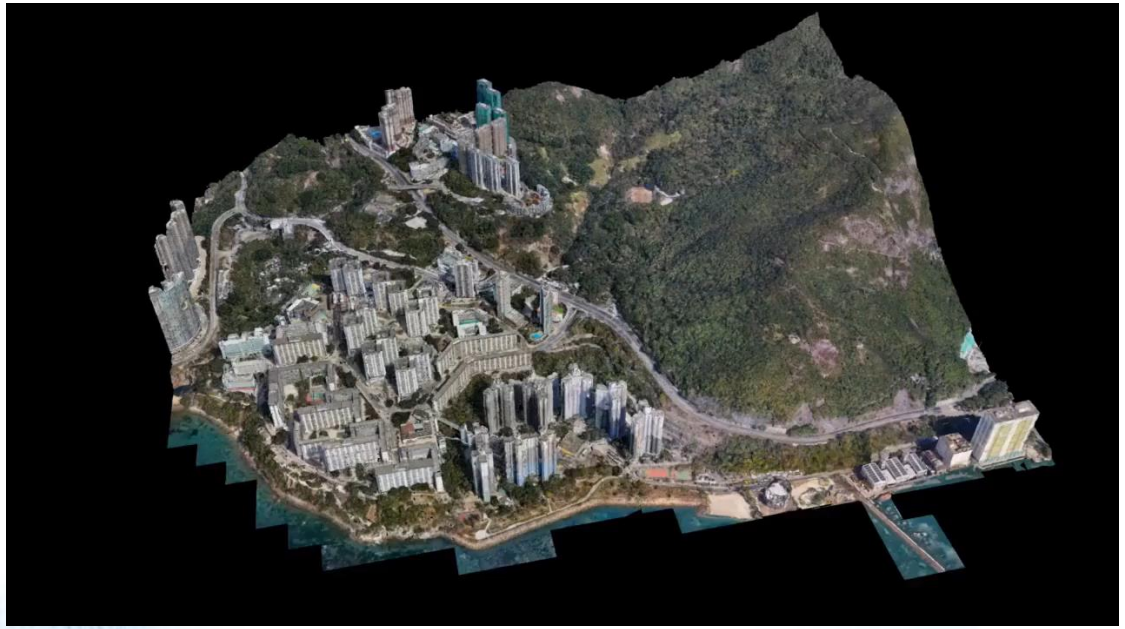
4. Unmanned Aerial Vehicle (UAV) for Inspecting the Building Envelope

香港房屋委員會
Hong Kong Housing Authority

Non-construction Application of UAV

3D Photorealistic Mesh Modelling

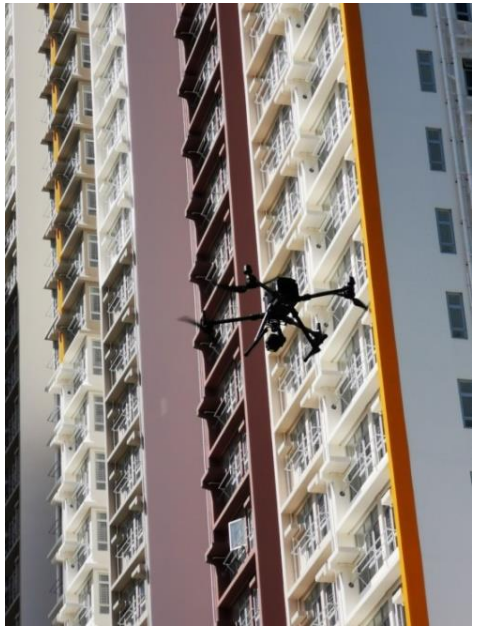
- Wah Fu Estate



~~External~~ Wall Inspection

- Defect detection near completion stage

at Hang Kin Street Public Housing Developments



UAV & Artificial Intelligence (AI) with BIM

How to Conduct External Wall Inspection:

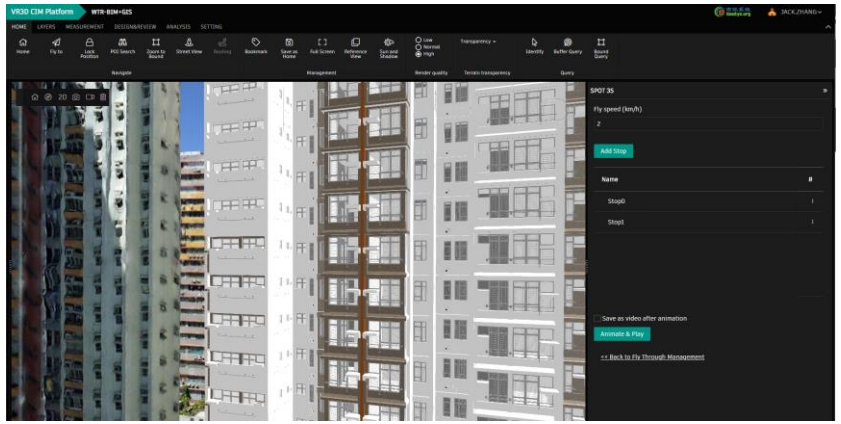
- Firstly, **UAV** to scan building external condition of each floor with high resolution data acquisition

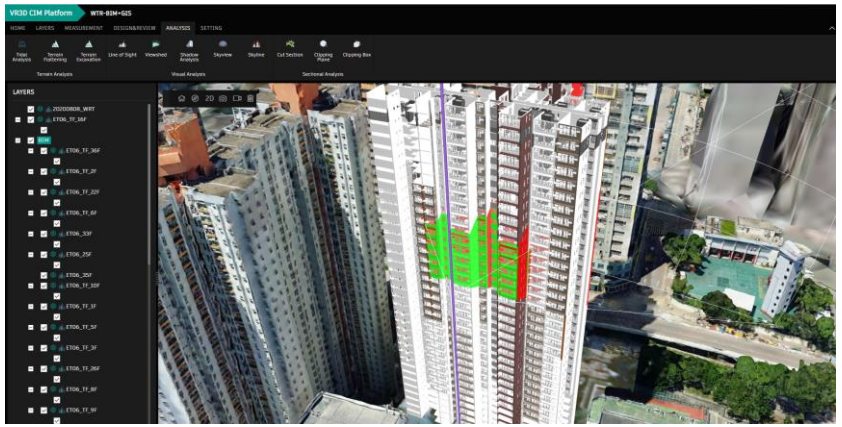
- Next, **AI** to detect defects with locations shown on the BIM/GIS model

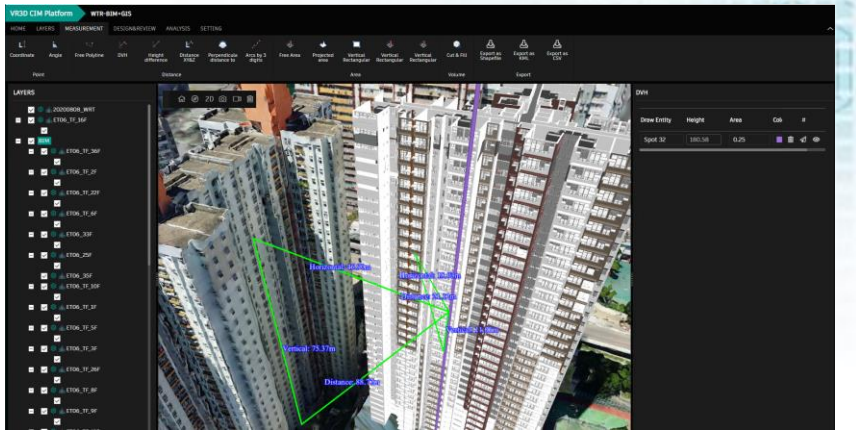
4. UNMANNED AREIAL VEHICLE (UAV) FOR INSPECTING THE BUILDING ENVELOPE

香港房屋委員會
Hong Kong Housing Authority

UAV Operation for Inspection of External Wall As-built Condition



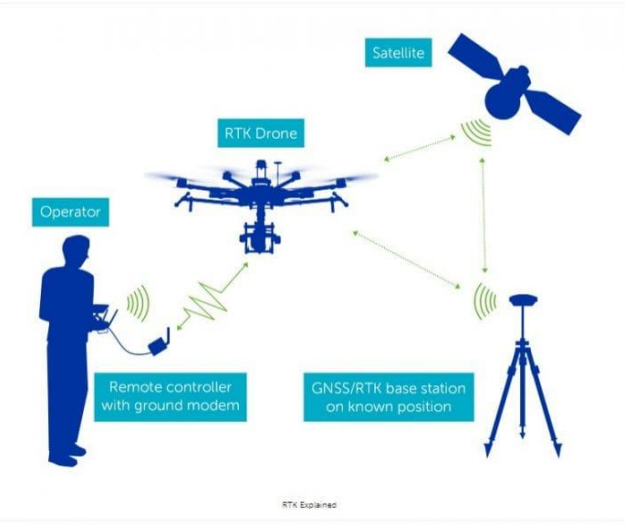




Use GIS+BIM model to create simulated video for view of each spot

Use GIS+BIM model to check whether UAV flight can capture the view

Measurement tools to check the distance to target/ground/buildings



4. UNMANNED AREIAL VEHICLE (UAV) FOR INSPECTING THE BUILDING ENVELOPE

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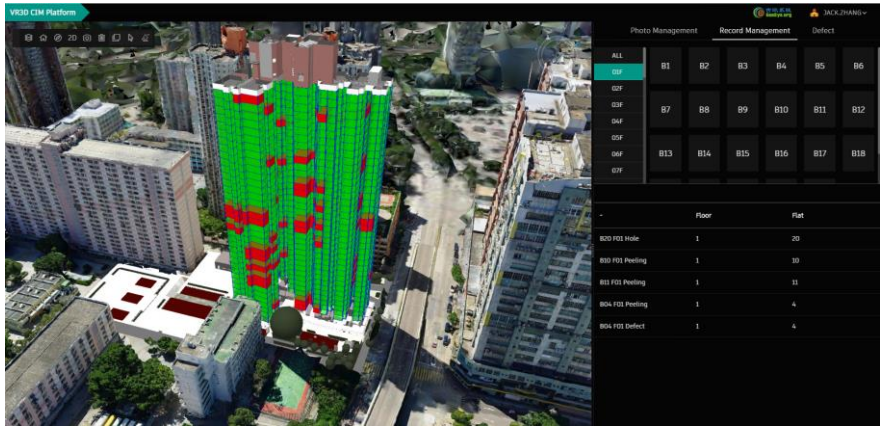
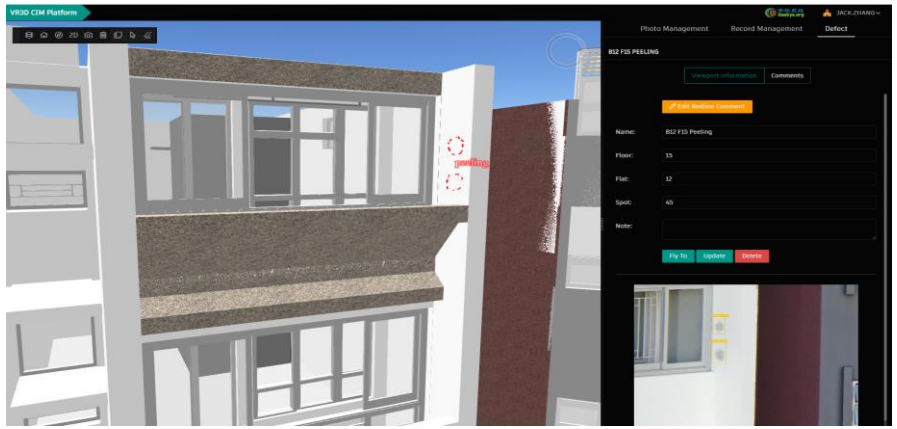
Defects Identification by A.I.





While the images captured by UAV are uploaded to Cloud, the AI will “match & locate” the images to the BIM model and generate the AI report .

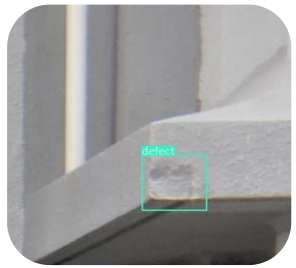
The AI will compare with BIM model and Reality Model and identify and trace the defects with marker tools

Major Types of Defects Identified by AI

Crack

Peeling

Hole



Defect

Risk

5. Reality Capture for Digitalising As-Constructed/Built Work

Towards the Age of Mobile Mapping

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Terrestrial Laser Scanner

One position captures millions of points

2000

Mobile Mapping

Continuous mapping captures millions of points from multiple positions

2015

Portable Mobile Mapping

Continuous mapping captures millions of points from multiple positions

2020+

Source: http://www.navvis.com/

Application in Public Housing Developments

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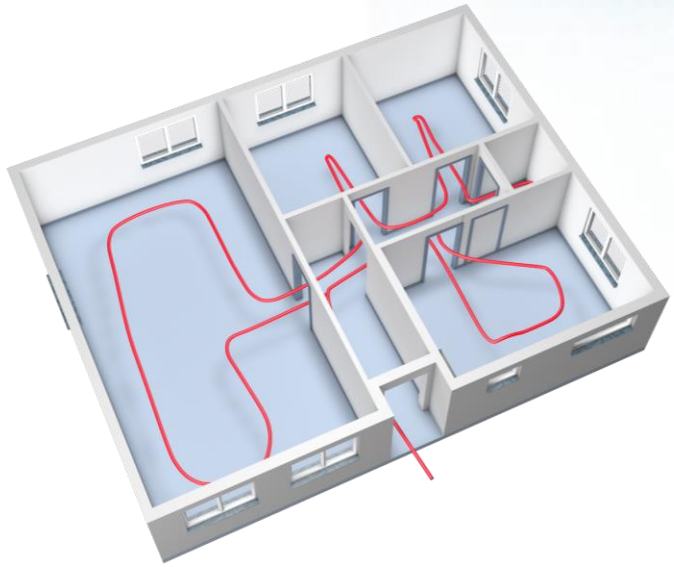
- Rapid on-site scanning of constructed works
- Scan 1-storey of 26 flats within **30 minutes**
- Applicable for quantity measurement and quality checking



Source: http://www.navvis.com/

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Video of scanning process at Chai Wan Road Public Housing Developments

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Virtual Site Visit
at Chai Wan Road Public Housing Developments

External Wall Drainage Inspection Tool

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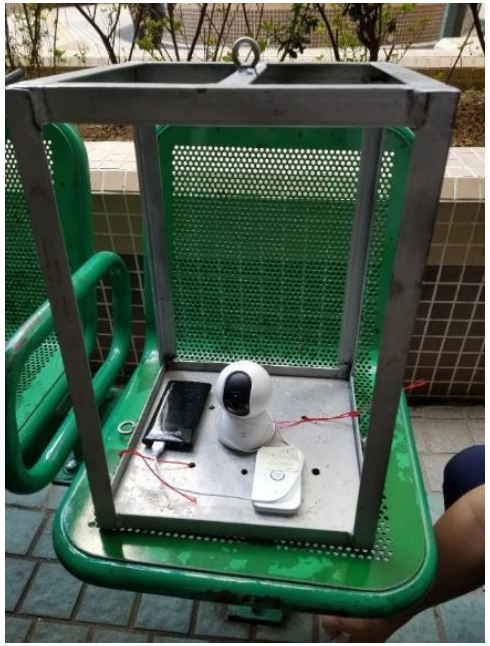
Trial at Upper Wong Tai Sin Estate

- close-up inspections to drain pipes at re-entrant
- identify the location of defective or unauthorized alteration of pipework

Setup at Main Roof



Cage with Camera and Wi-fi device

Inspection Tool at Re-entrant

Instant Image shown in the Apps

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6. Building Information Modelling (BIM) – Application & our Roadmap

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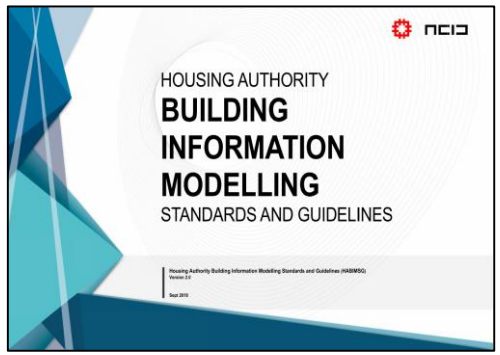
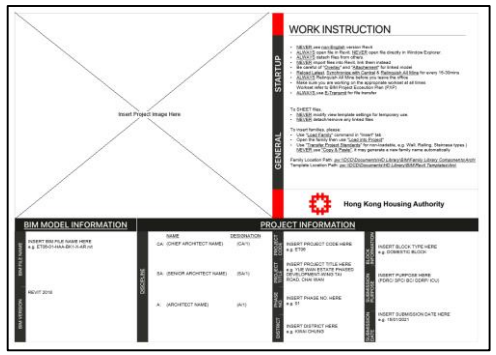
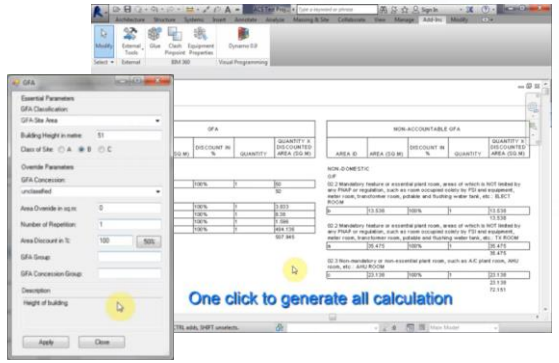
BIM for Drawing Production



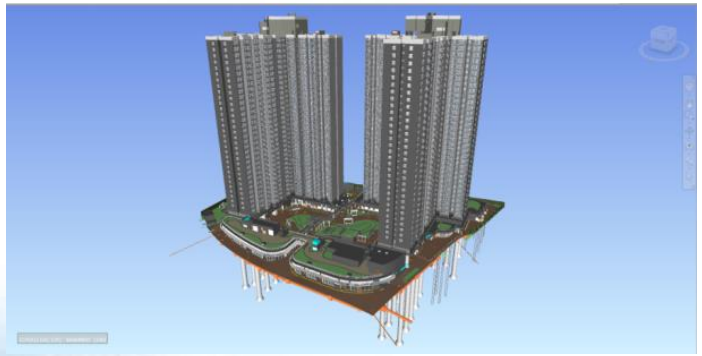
BIM Standards and Guidelines



BIM Templates



Software Plug-ins



Single source of truth

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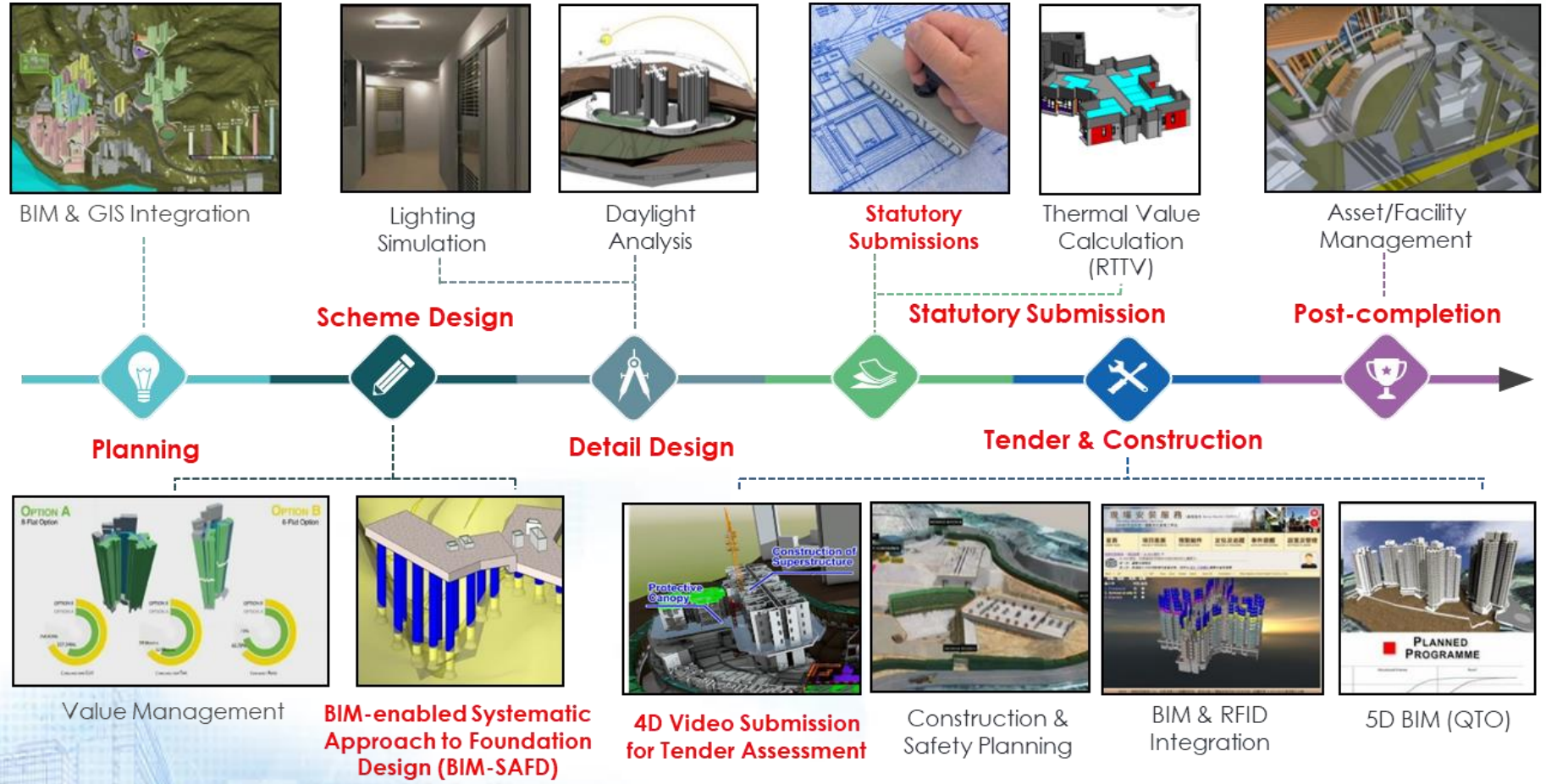
HA's BIM Applications

Our application encompasses full design and construction cycle.



OUR TARGETS

- Apply BIM to all our projects in 2021
- The extent of BIM application for each project would be determined based on individual projects

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Reality Capture - Scan to BIM Applications

Example 1: Laser Scanning for Tree at San Kwai Street Public Housing Developments

- Laser scanning was deployed to create a 3D models of a tree that was clashing with the proposed lift tower;
- With the 3D tree model, our Landscape Architect could easily determine the required extent of tree-pruning to avoid clashing with the proposed lift tower.

BEFORE

AFTER

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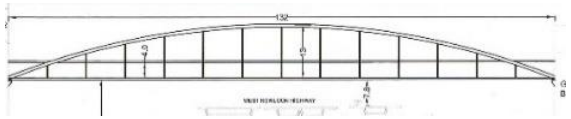
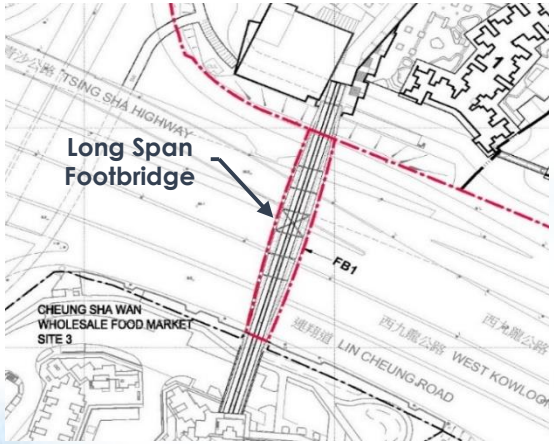
Reality Capture - Scan to BIM Applications

Example 2: As-built Verification of Long Span Footbridge at Hoi Tat Estate

BEFORE

Traditional 2D plan & section plan





NOW

BIM to simulate the in-place installation

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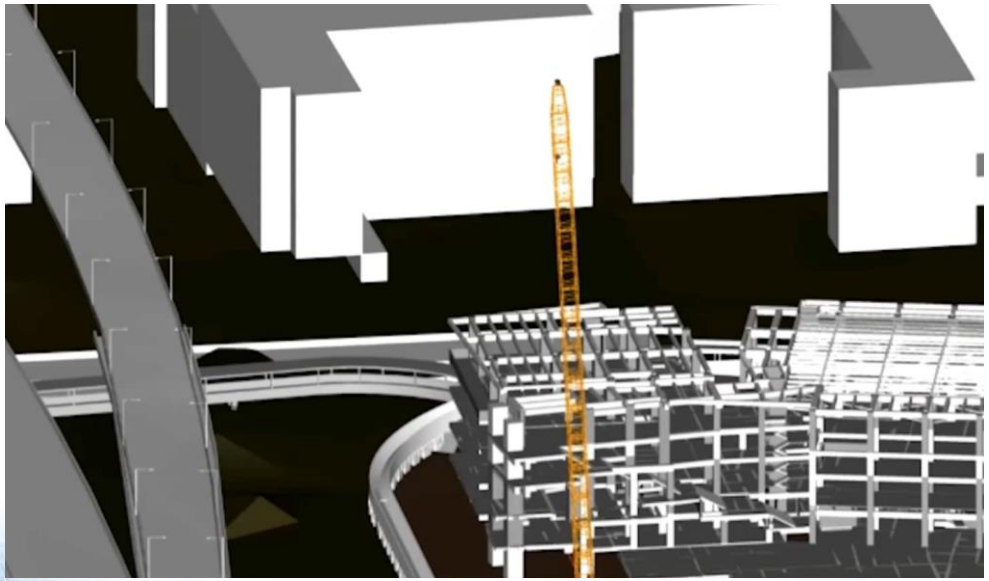
Reality Capture - Scan to BIM Applications

Example 3: BIM Simulation for Actual Site Operation at Hoi Tat Estate

Planning by BIM Simulation



Actual Site Operation

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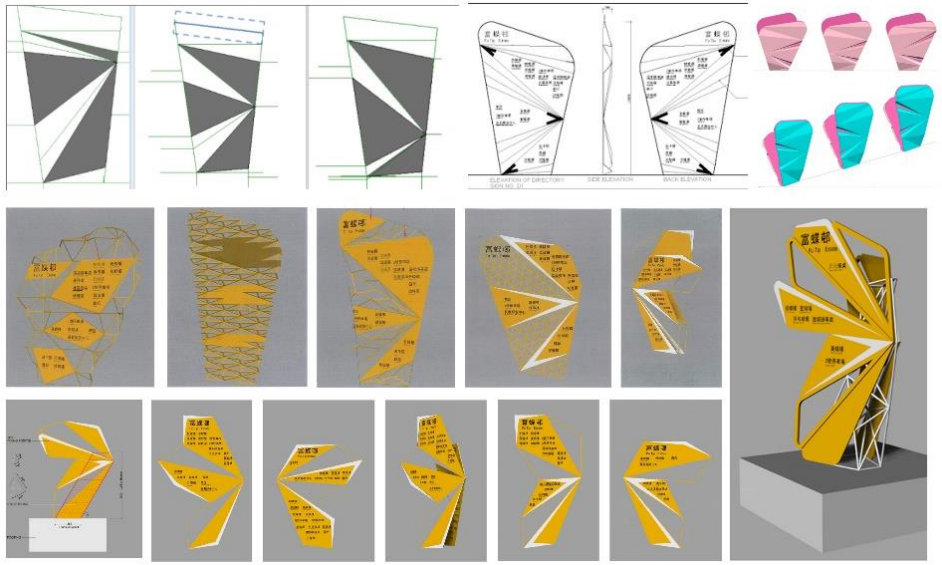
Generative Design

Generative Design is a design process exploring for all possible permutations of a solution and quickly generating design alternatives.

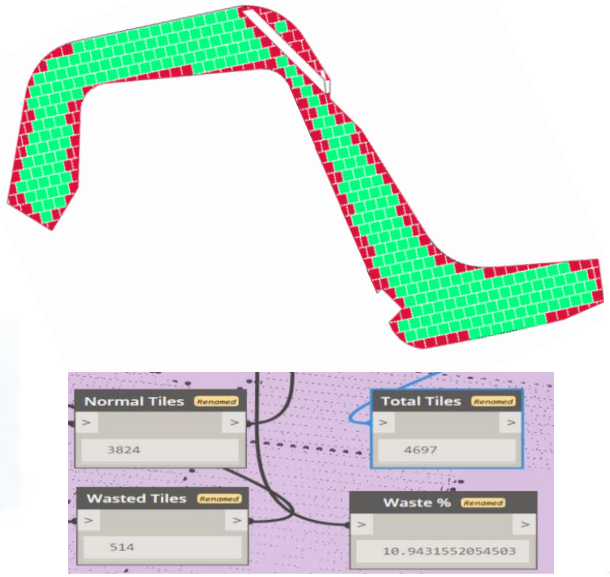
We wish to explore the generative design to assist our works in the following areas:

- **Architectural** (Landscape design, Signage & Paving Design);
  Trial at Tai Po Public Housing Developments (below)

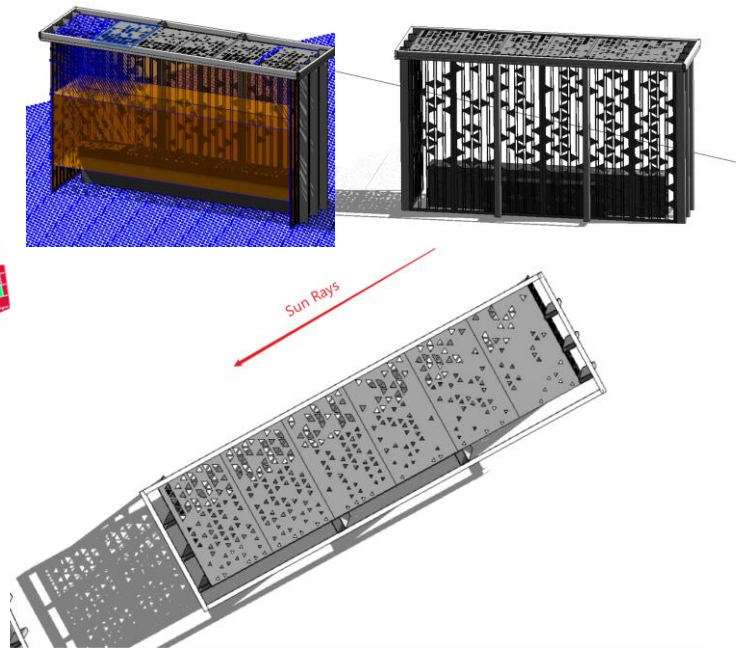
Signage Design



Paving Design



Trellis Design



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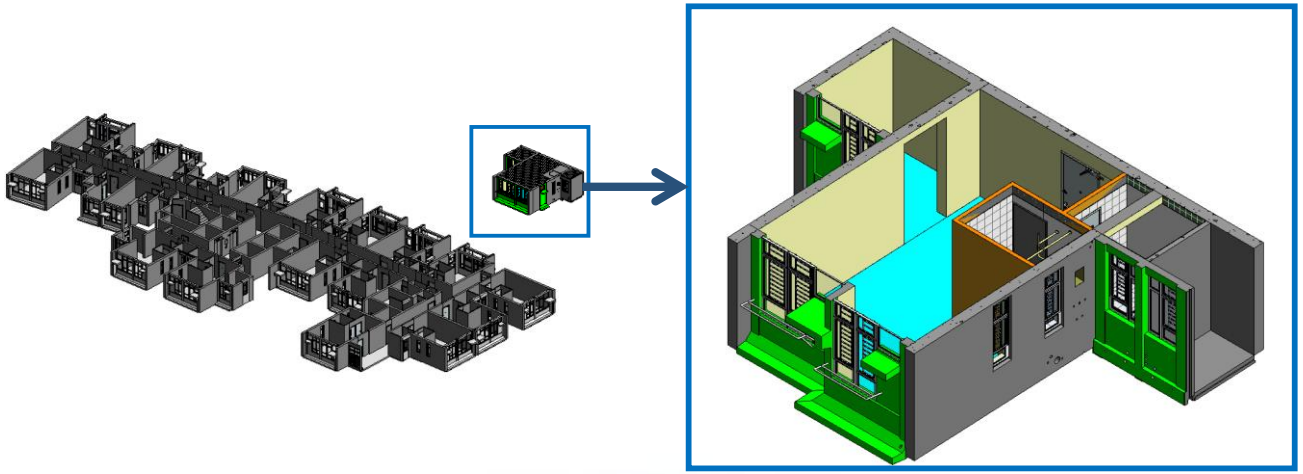
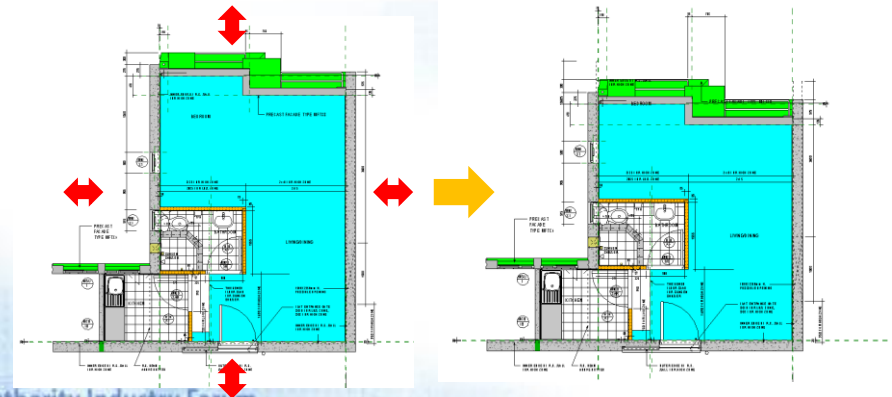
Generative Design

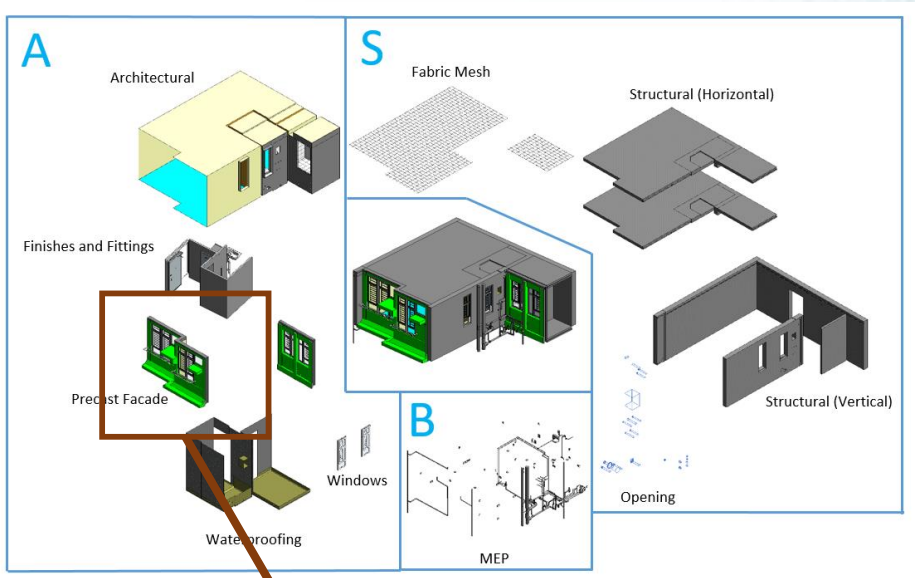
- **Architectural** (Modular Flat Design)

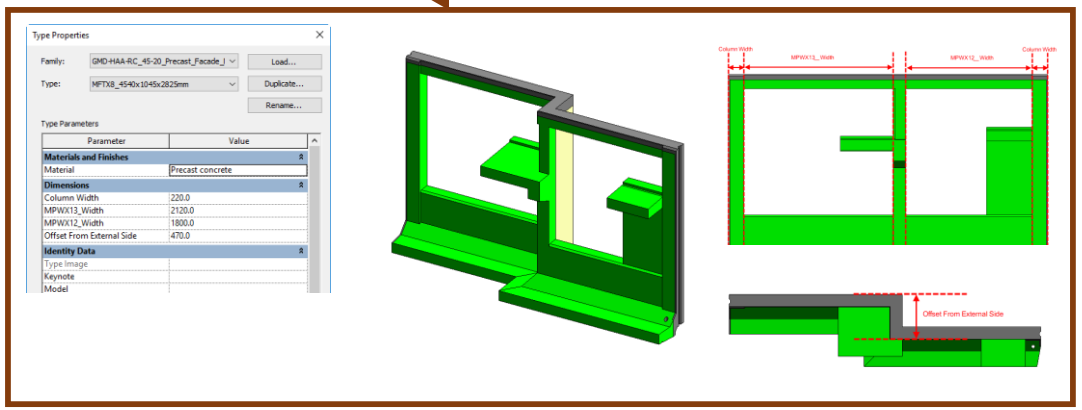
Parametric MFD





Collaboration of MFD data Set & Flat Mix Analysis





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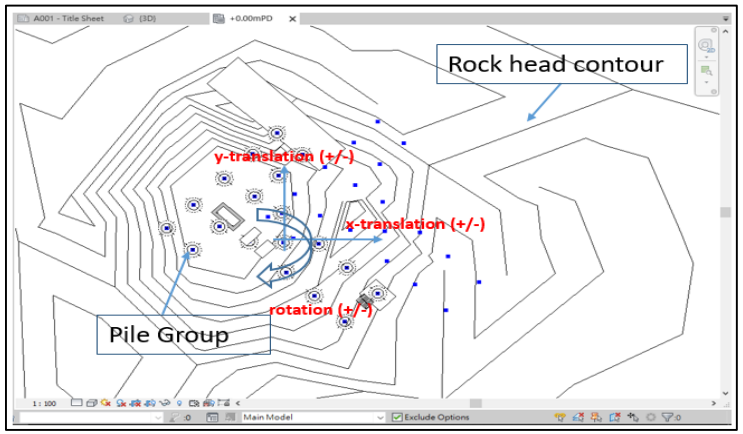
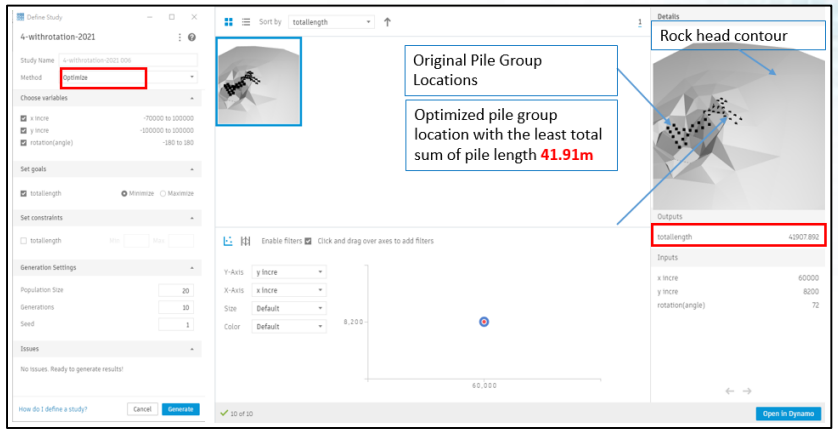
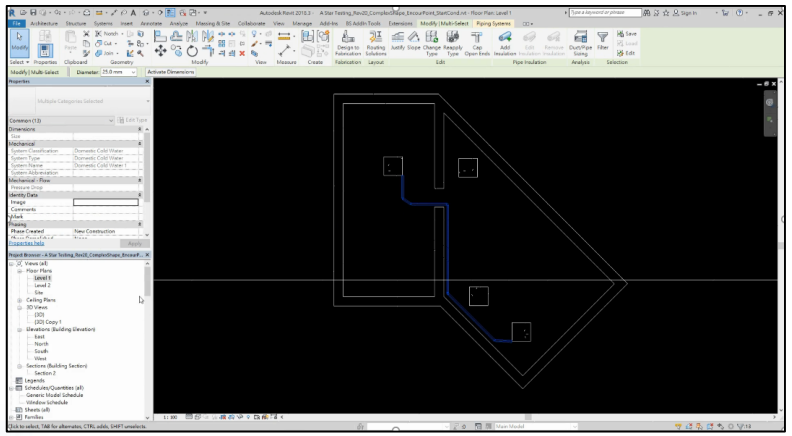
Generative Design

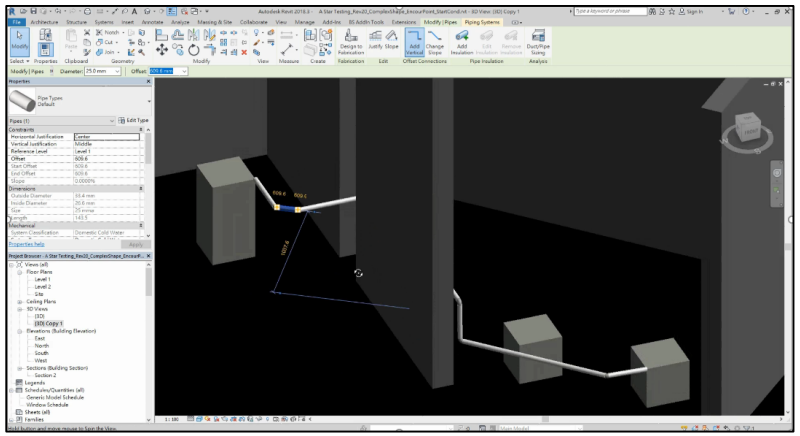
- **Structural Engineering**
  (Foundation Design)





- **Building Services Engineering**
  (Service Routing Design)





7. Looking Forward

7. LOOKING FORWARD

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From Digitisation to Digitalisation through wider use of construction robotics, DCSMS, UAV, remote sensing technology and BIM for construction industry in Hong Kong

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Thank You

Hong Kong Housing Authority Industry Forum
Innovative Construction Methods for Public Housing Developments 2021