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**MODULAR INTEGRATED CONSTRUCTION
FROM SINGAPORE TO HONG KONG
FROM PRECAST TO MIC
SHARING OF EXPERIENCE**

17 Sep 2019



Outline of Briefing

Evolution from precast to concrete MiC

Progress from PVC to PPVC in Singapore

From Singapore to Hong Kong

Challenges to HK Concrete MiC

Possible Solutions



Concrete MiC

Similar touch and feel as conventional construction

Less complicated fire proofing work

Relatively maintenance free compared to steel MiC

Heavy modules, normally exceed 20 tons

More labour usage compared to steel MiC

Slower to install compared with steel MiC

Dominant type of MiC used for residential development



Precast to MiC – some milestones

Singapore HDB Tampines N4C24 – precast beam, slab and wall



1992

Singapore Woodvale Exec Condominium – precast column, beams and slab



2001

Hong Kong Grandeur Terrace
Precast slab



2003

Singapore Park Green Exec Condominium – precast shear wall, columns and fascade



2005

Mapletree Business City – precast hollow core slab



2010

2011 to present Singapore 35 Public Housing Projects comprising >13,000 homes – precast beam, slab, column and wall



2011

Singapore The Crest Condominium Project – precast biaxial voided deck, shear wall, balcony, fascade



2013

Hong Kong Shatin 36C Subsidised Housing Project – precast structural wall



2014

Singapore HDB Bukit Batok N4C11
PPVC construction



2015

Singapore Canberra Drive
Condominium PPVC construction



2015

Hong Kong Matrix Deck - Breast Cancer
Foundation



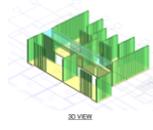
2017

Hong Kong, Pre-acceptance submission for
steel MiC system



2018

Hong Kong, Pre-acceptance submission for 40 Sty
Concrete Mic Building, HK patent appln no.
18114717.3



2018

Hong Kong, Pre-acceptance submission for 20S
Steel / Aluminium Mic system, HK patent temp
appln no. P6001



2019



Precast Structures (1990 – 2000)



- Non-structural facade
- Structural semi-slab
- Structural staircase
- Structural beams

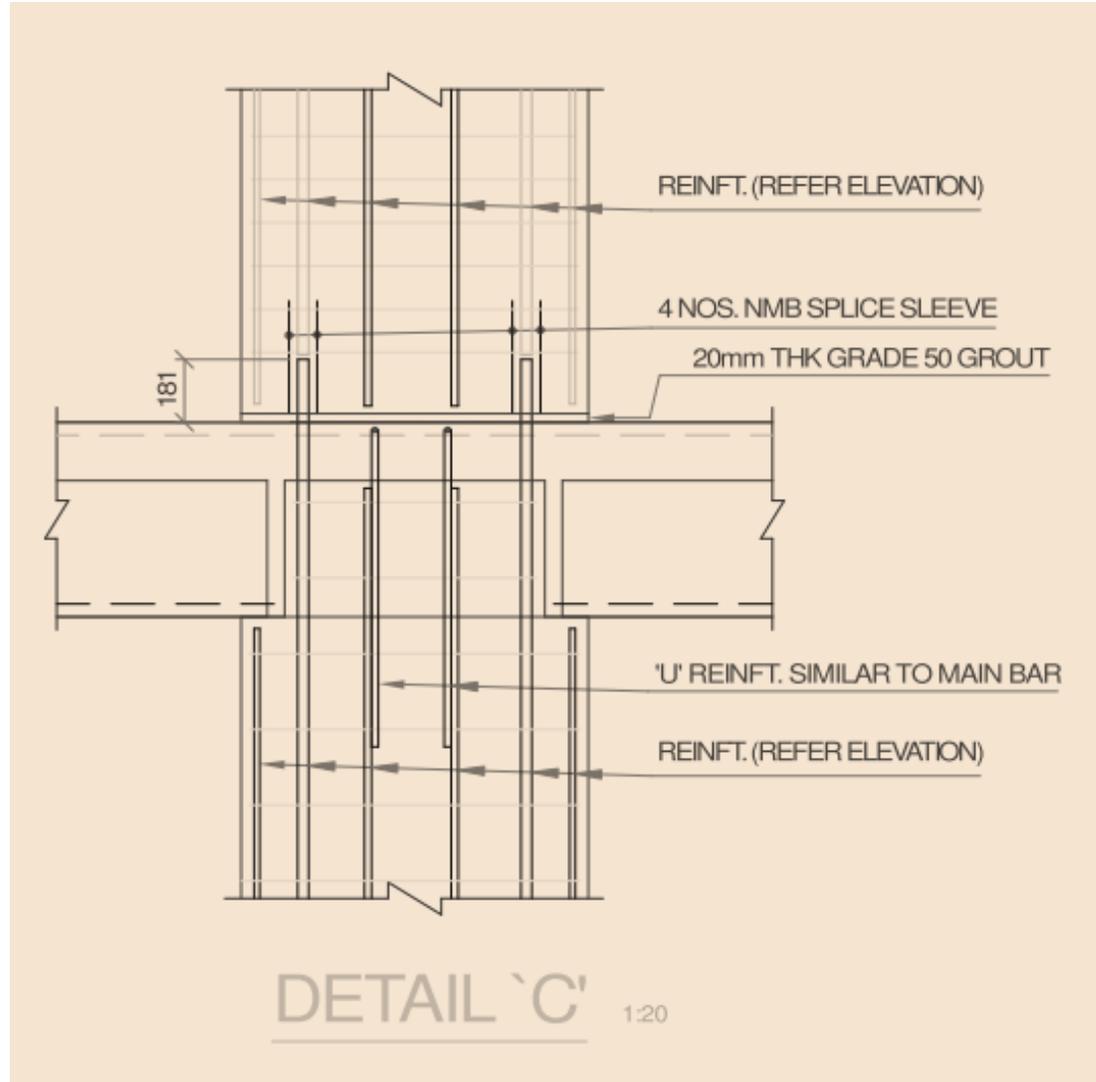
Similar detailing as cast in situ concrete
Void out some parts to be cast at site



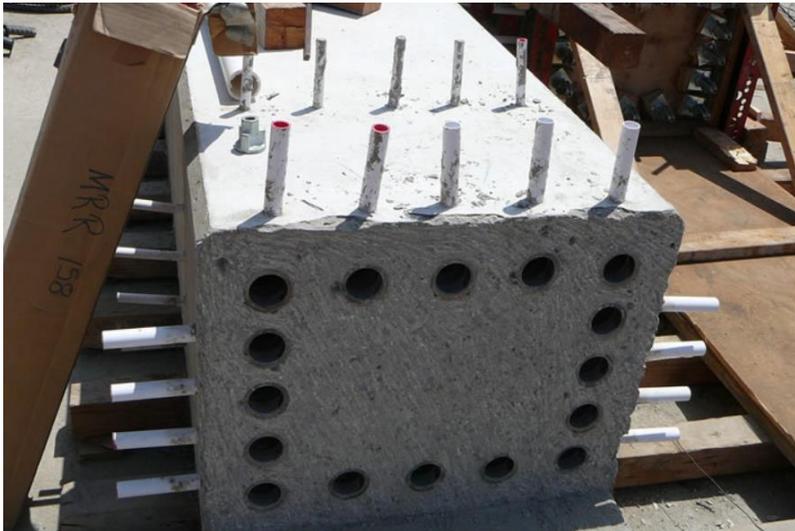
Precast Structure (2001 – 2005)



Short starter bars < 200mm



Precast Columns connected with grout filled pipe sleeve

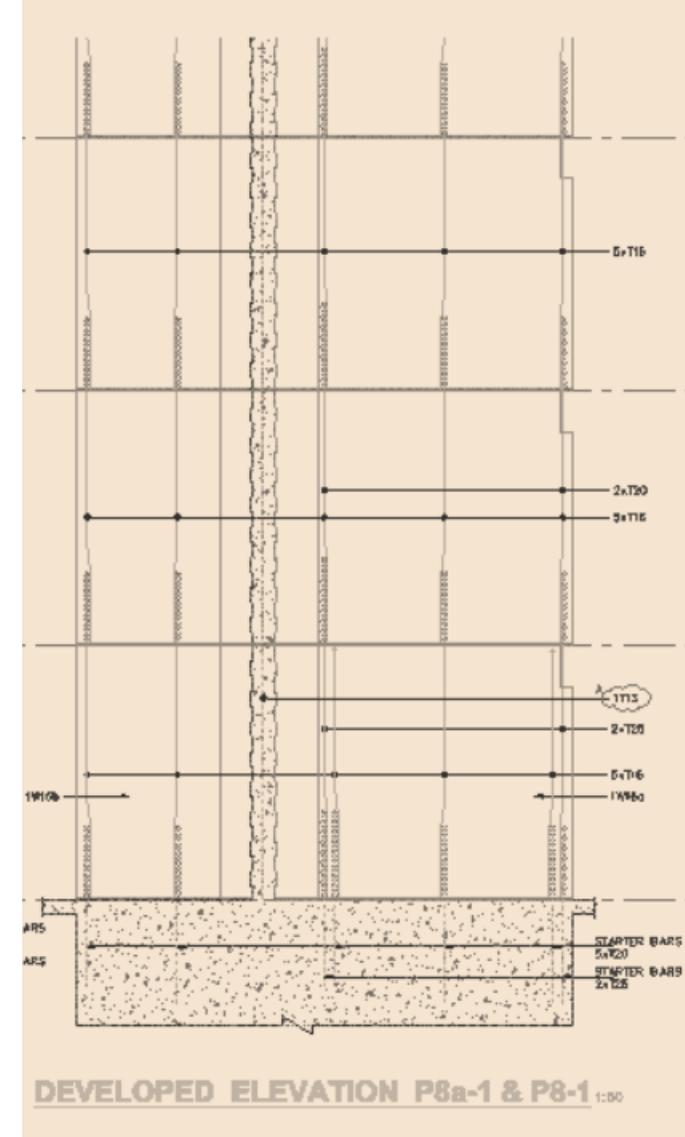
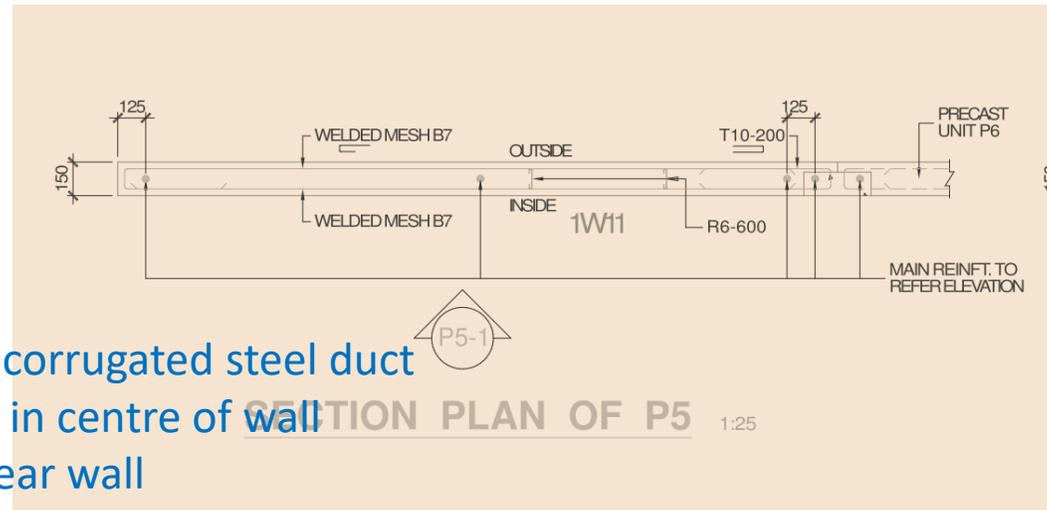
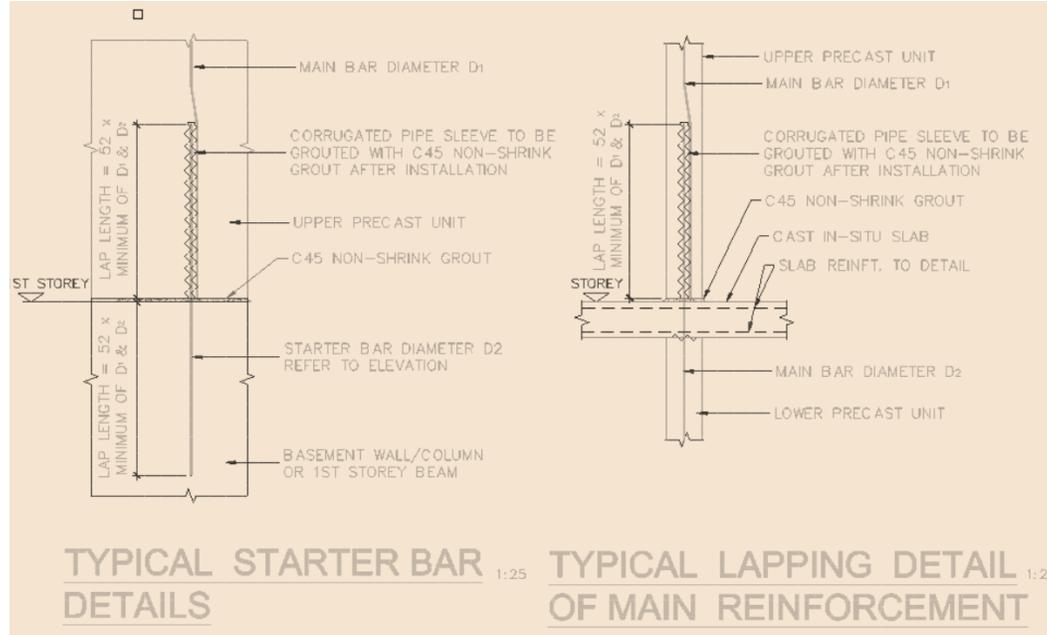


- Suitable for precast applications
- Monotonic and cyclic loading tests
- Seismic area application

Already widely used in many countries



Precast Structure (2001 – 2005)



Precast shear wall connected with corrugated steel duct
 Single layer of main reinforcement in centre of wall
 Minimum 150mm thick precast shear wall



Precast Structure (2001 – 2005)

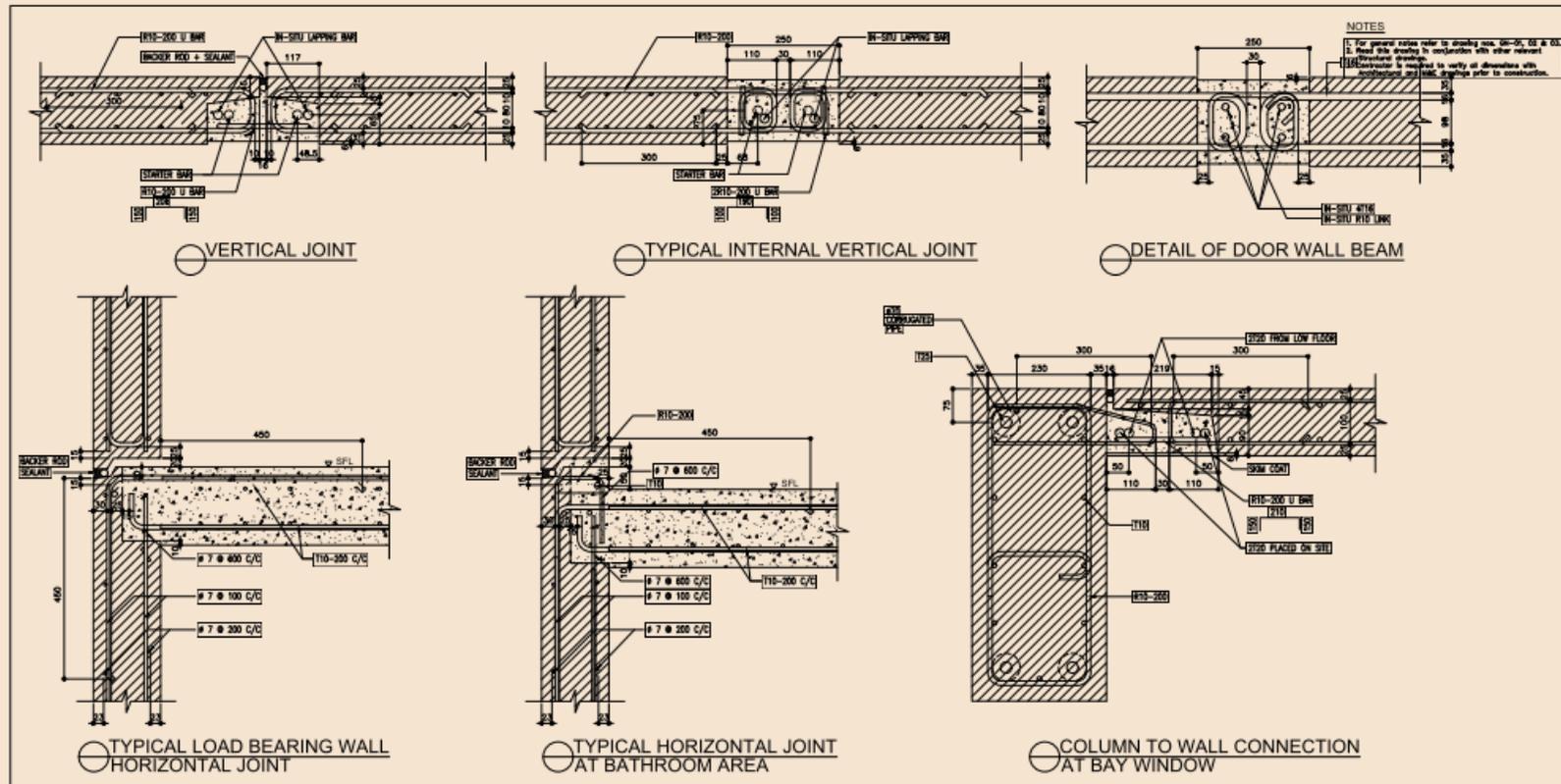


Fig. 6.9 – Lowering of precast wall panel during installation

- Other connection details
- Avoid overlapping bars
- Reduced site formwork



Singapore Public Housing > 13,000 units (from 2012)

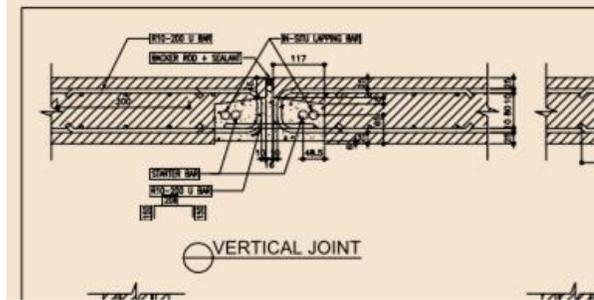


- Precast columns
- Precast shear walls
- Precast beams
- Precast half slabs – prestressed and non-prestressed
- Precast volumetric household shelter
- Grout filled pipe sleeve couplers

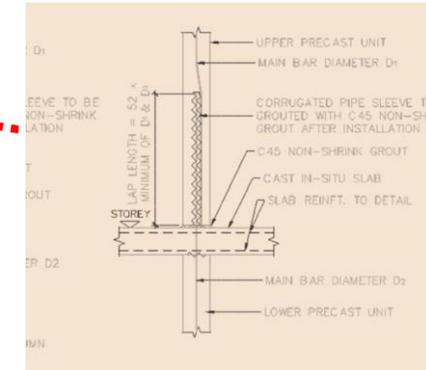
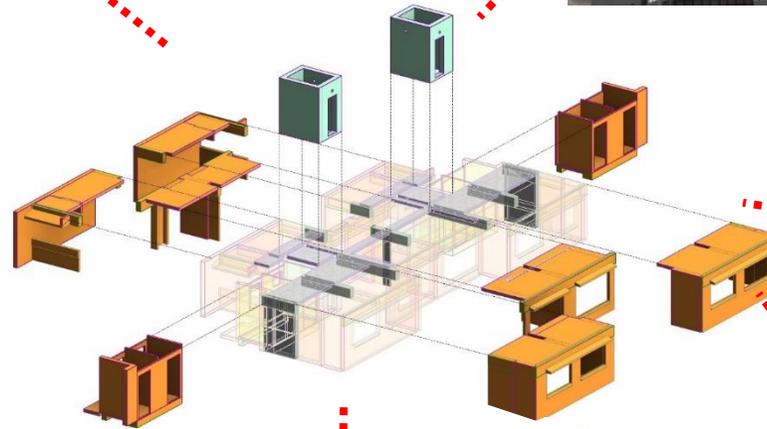
wide application of precast design



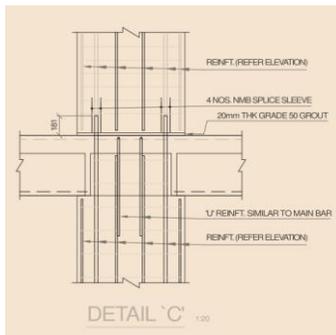
West Terra (2013) – beginning of PPVC



- First PVC project in Singapore
- Precast Volumetric Construction with PBU
- Predecessor to PPVC
- Previously used precast design details
- Gantry crane hoisting solution
- 3D casting techniques



HS, PBU & PVC Components managed by Assemblies

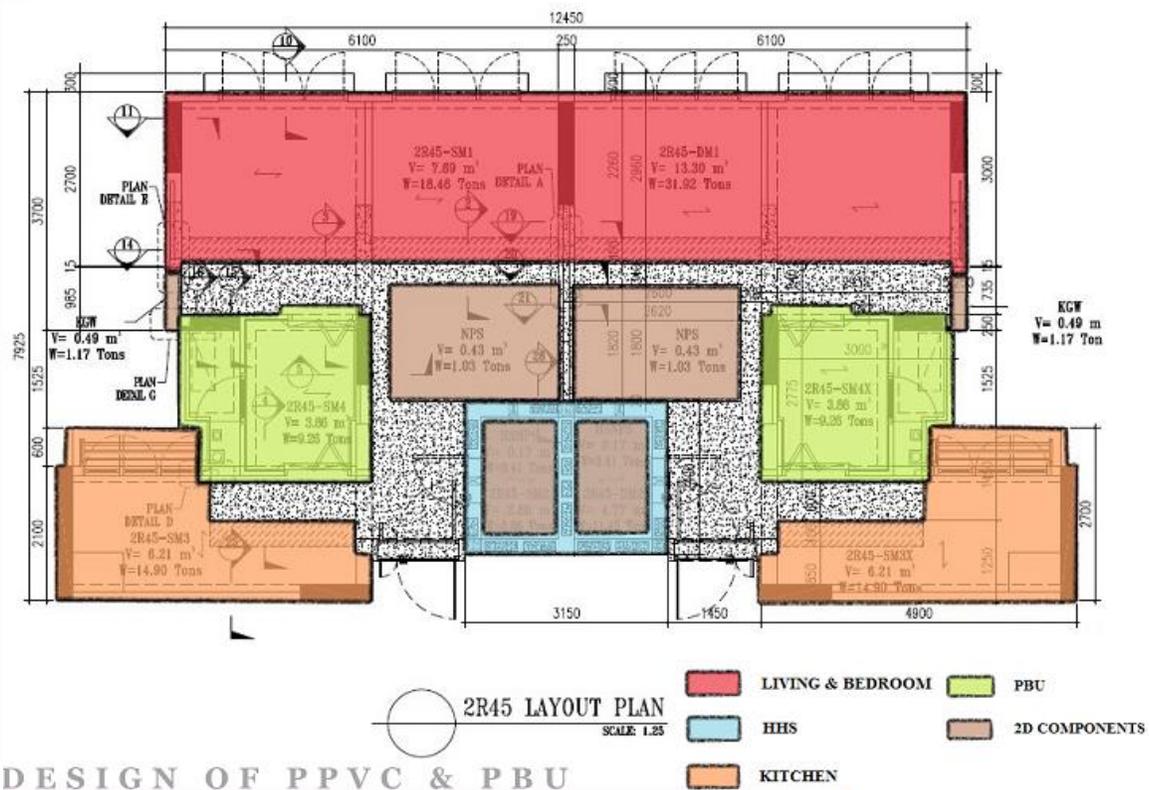




West Terra (2013) – beginning of PPVC



LAYOUT IDEAS FOR 2-ROOM (TYPE 2)
APPROX. FLOOR AREA 47 sqm
(Inclusive of Internal Floor Area of 45 sqm and Air-con Ledge)



PVC + PBU + cast in situ strips



West Terra (2013) – beginning of PPVC



wall joint using grouted
corrugated duct



Wall vertical joint

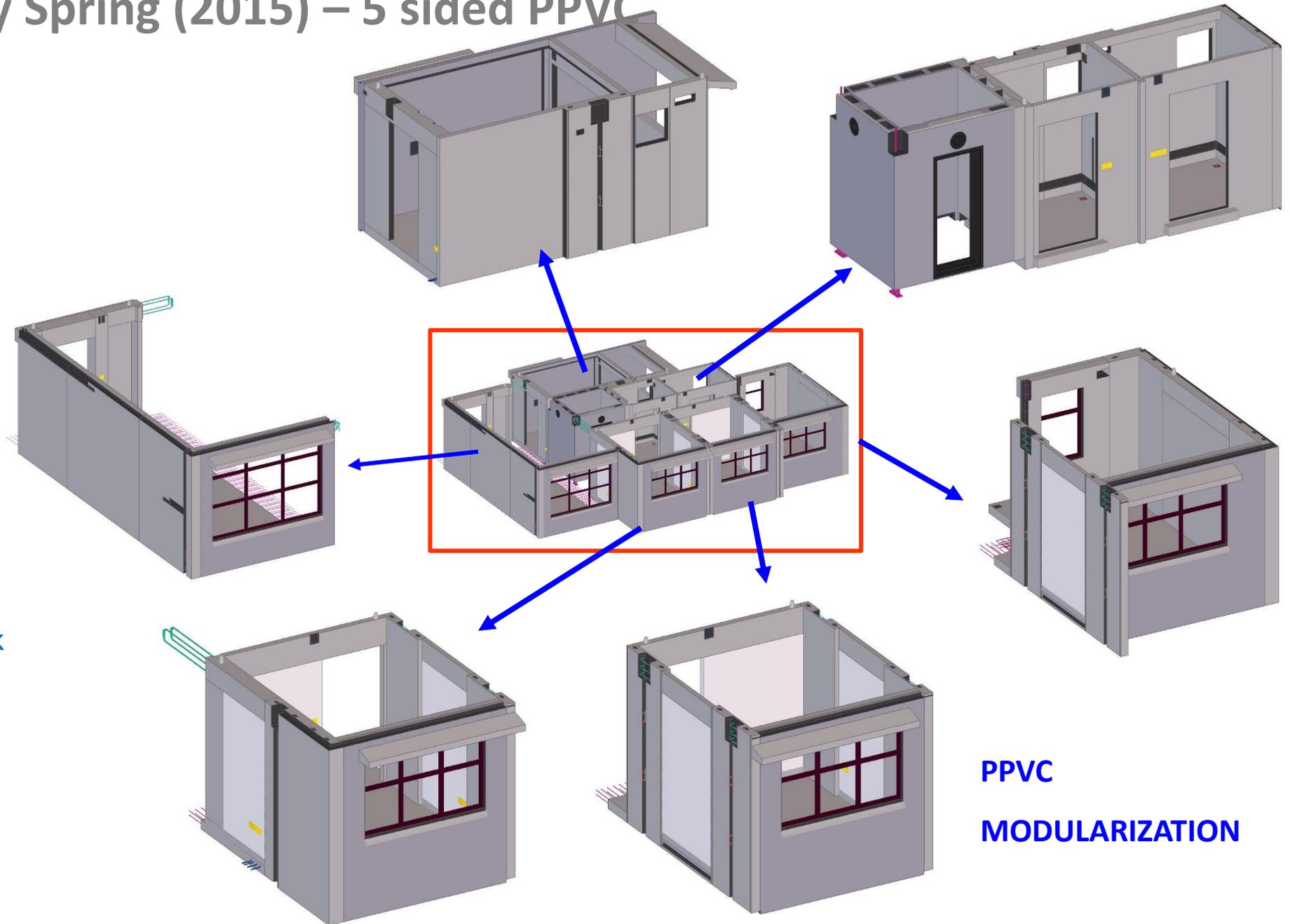


slab joint

- Structural connections carried out inside module
- Finishes limited to PBU (Precast bathroom unit)



Yishun Valley Spring (2015) – 5 sided PPVC

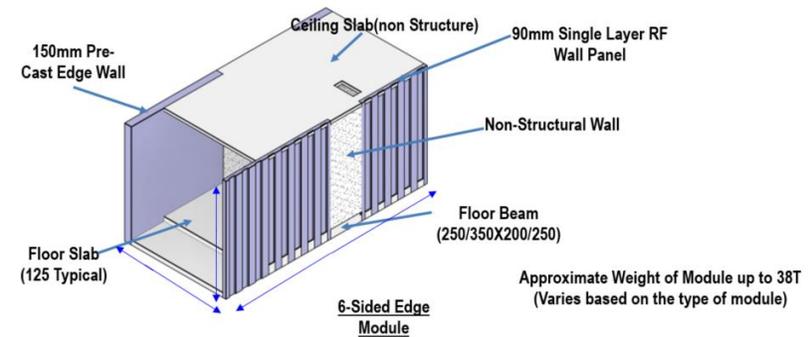
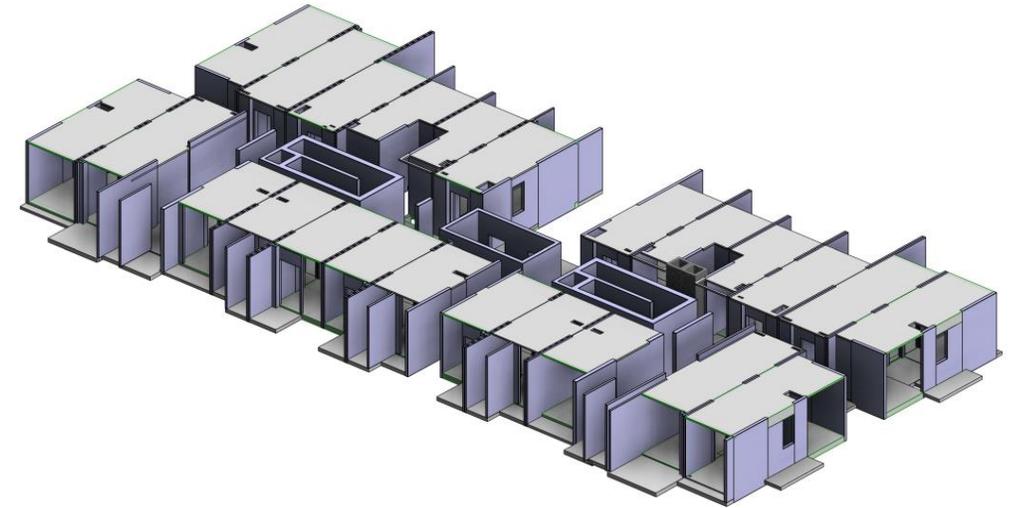


U shaped 5 sided modules
Non-composite wall
Floor finishes and MEP work
completed at factory

**PPVC
MODULARIZATION**



The Tapestry (2016) – 6 sided PPVC



- 6 sided modules
- Composite structural wall
- Finishes and MEP substantially completed at factory



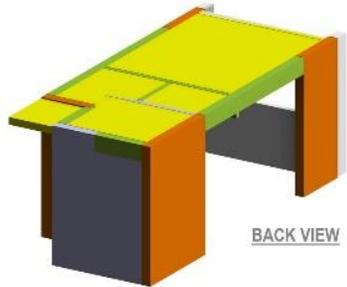
The Tapestry (2016) – 6 sided PPVC



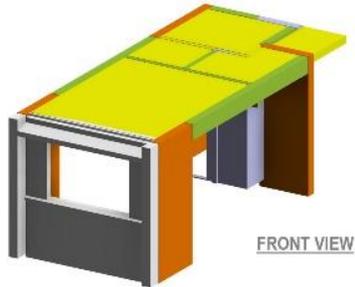


From PVC to PPVC

N Shape

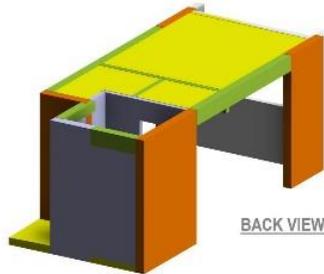


BACK VIEW

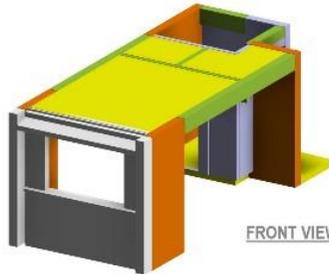


FRONT VIEW

N+U Shape

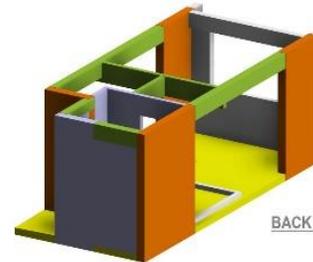


BACK VIEW

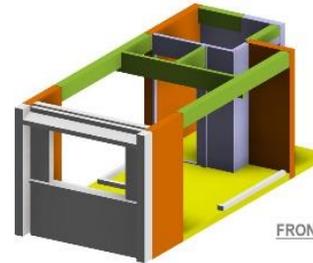


FRONT VIEW

U Shape

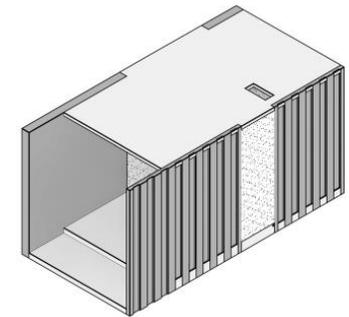


BACK VIEW



FRONT VIEW

6 Sided



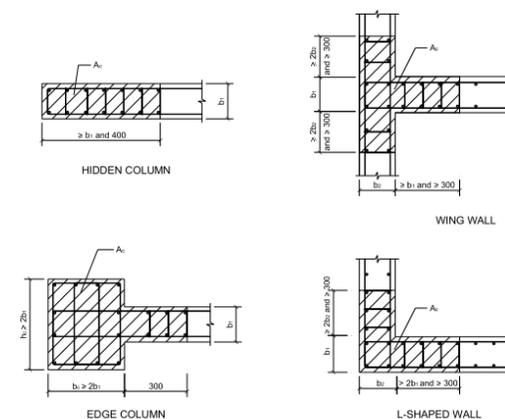
Complexity of structural connections
Weight of module
Work completed at factory





From Singapore to Hong Kong

Comparison	Singapore	Hong Kong
Code or Practice	EC1 EC2	COP for Structural Use of concrete 2013 COP for Precast Concrete Construction 2016 COP on Wind Effects in HK
Design Hourly mean wind speed at 10m	18.4 m/s	38.7m/s
Limits to compression ratio	NA	SUC cl. 9.9.3.3
Confined boundary zone	NA	SUC 9.9.3.4 to 9.9.3.6 150mm link spacing



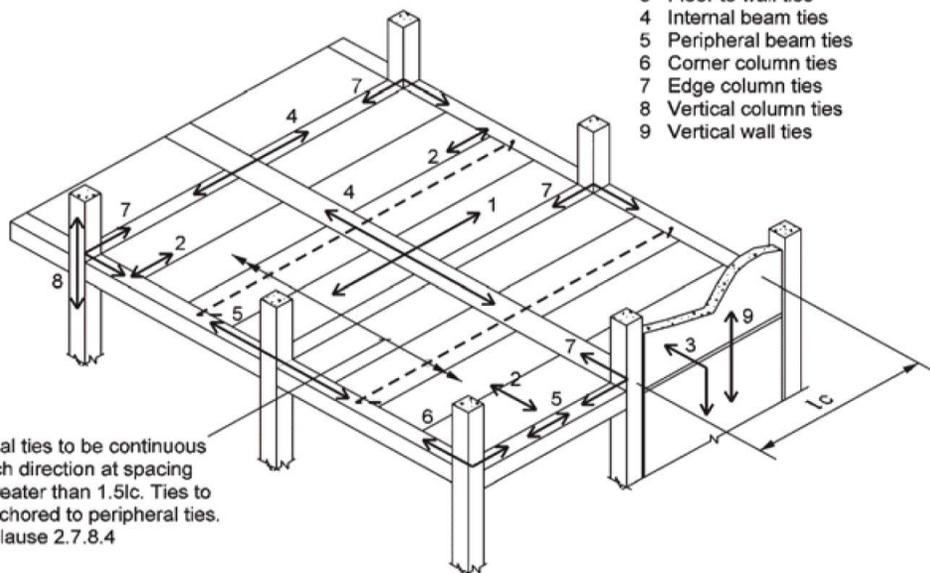
(b) Type 3 confined boundary elements



From Singapore to Hong Kong

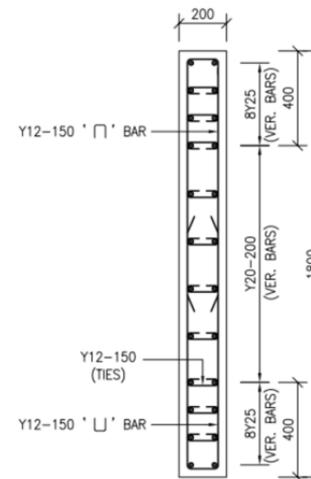
Key to ties

- 1 Internal floor ties
- 2 Peripheral floor ties
- 3 Floor to wall ties
- 4 Internal beam ties
- 5 Peripheral beam ties
- 6 Corner column ties
- 7 Edge column ties
- 8 Vertical column ties
- 9 Vertical wall ties



Internal ties to be continuous in each direction at spacing not greater than $1.5l_c$. Ties to be anchored to peripheral ties. See clause 2.7.8.4

Note: \leftrightarrow Denotes indicative location of tie. Ties can be located within insitu topping or partly or wholly within precast unit as appropriate, see clause 2.7.8.1. Ties to be continuous.



PLAN OF T1W29 WALL DETAILS

(FROM LEVEL +31.450 TO 6/F)

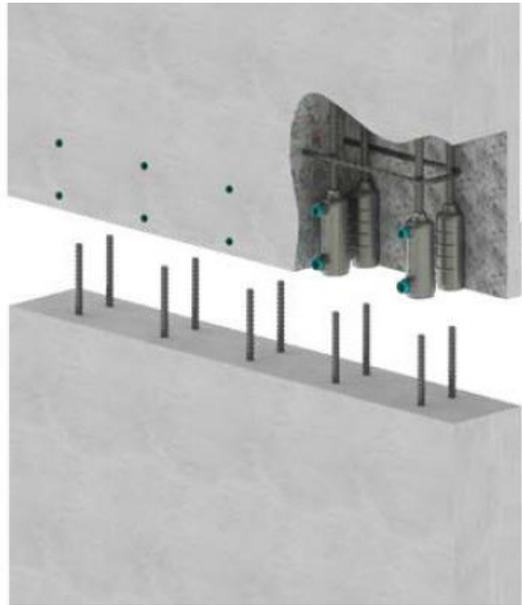
1 : 20

Robustness - Provide effective periphery and internal ties to Cl.6.4.1

- Heavier reinforcement required in HK (2 to 3%) compared to less than 1.5% in Singapore
- Ties at 150mm spacing required in wall confinement boundary zone
- Details in Singapore practice need to be developed to be applicable to Hong Kong

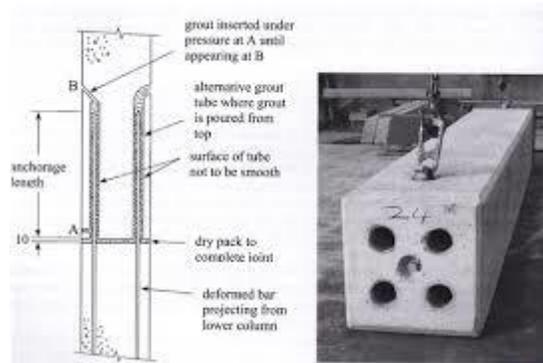


Challenges to Concrete MiC Design in Hong Kong

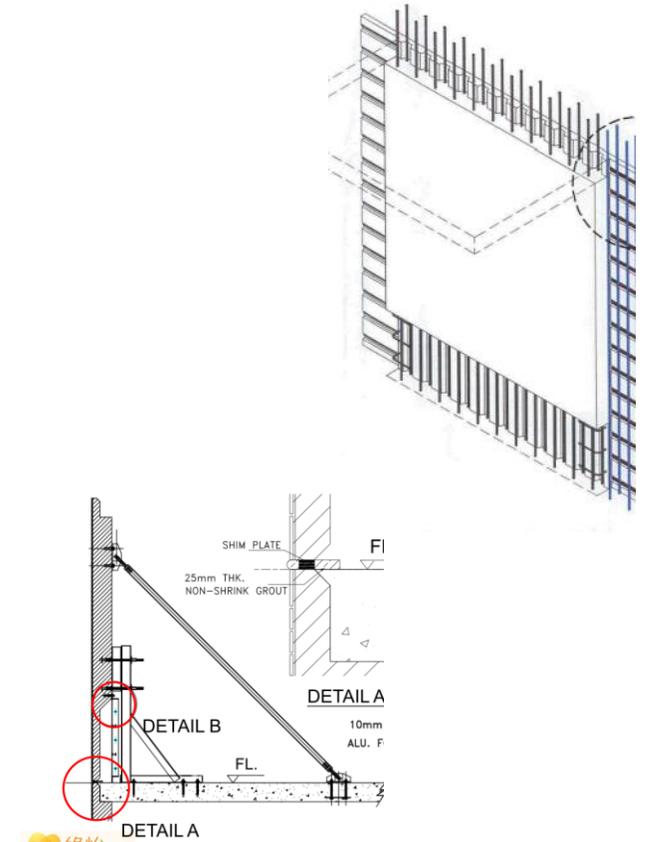


Typical wall connection

Grout filled pipe sleeve couplers



Lapping in grout filled corrugated ducts



Semi-precast structural wall
Lapping reinforcement joint
HKCOP Precast Concrete
2016

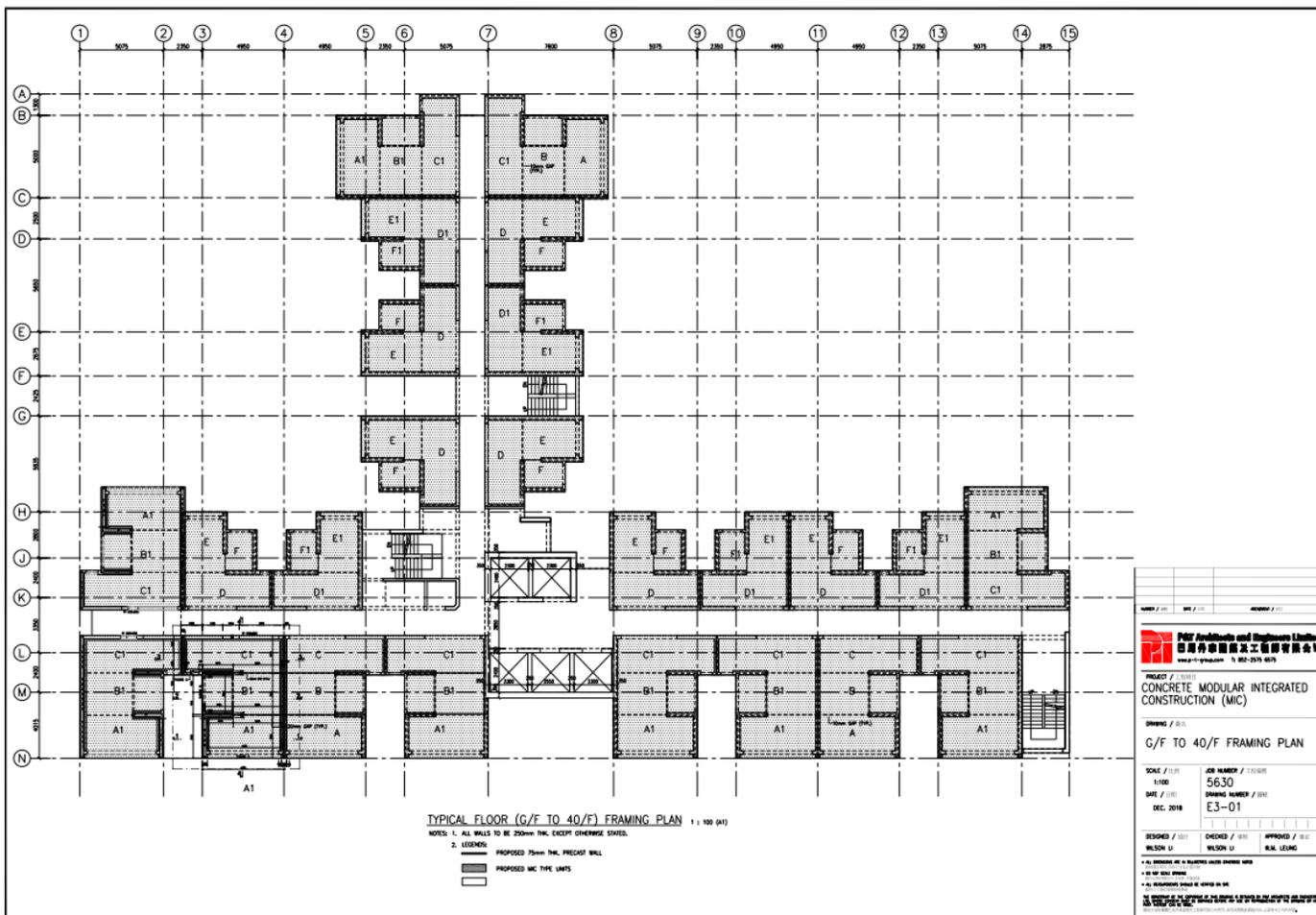


Challenges to Concrete MiC Design in Hong Kong

- More structural walls within units compared to conventional
- Non-composite double wall results in more loss of area
 - e.g. consider module size 2.5m x 8m
 - additional wall thickness 100mm on two sides
 - loss of usable area = $(10.5\text{m} \times 0.1\text{m}) / 2.5\text{m} / 8\text{m} = 5.25\%$
- Can the GFA incentive sufficiently compensate the loss of usable area?
- Structural walls cannot be removed in future – affect flexibility of A/A in future
- Width of modules up to 2.5m for day time transportation, clear width of rooms < 2.3m
- wider rooms cannot be MiC? Difficult to mix MiC and cast in situ construction in close proximity
- Residential development forms the bulk of construction in HK, need to find a feasible MiC solution



Possible Solutions

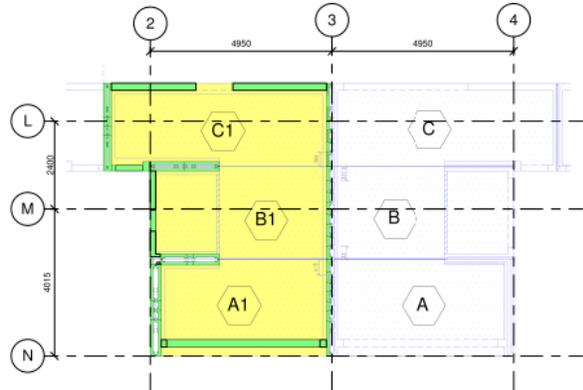


40 storey RC MiC submitted to BD for pre-acceptance approval

Composite structural wall minimise aggregate thickness of wall and reduce loss of area

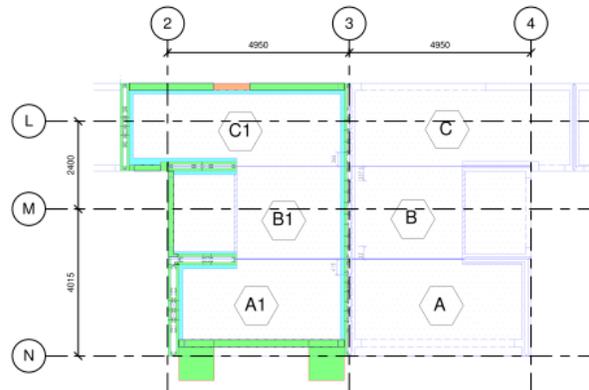


Possible Solutions



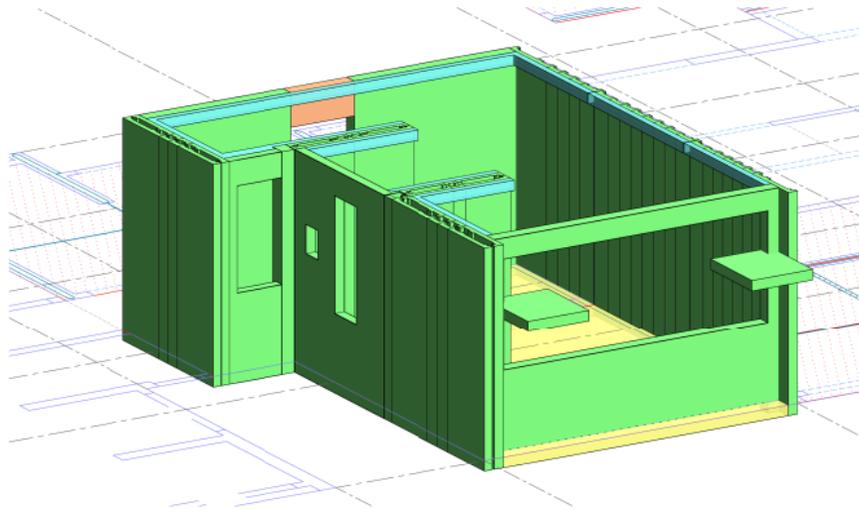
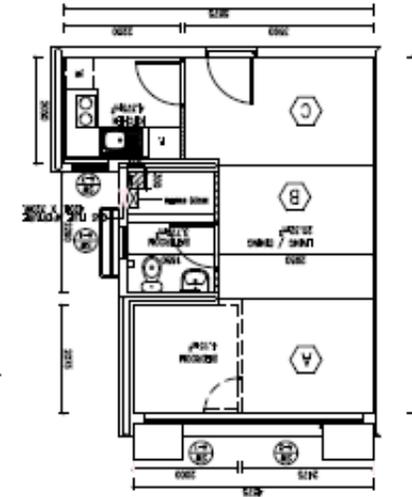
MIC MODULES TYPE (A1 / B1 / C1) BOTTOM PLAN

1 : 100

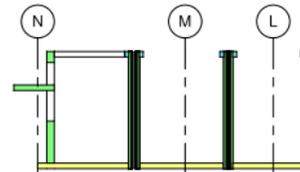


MIC MODULES TYPE (A1 / B1 / C1) TOP PLAN

1 : 100



3D VIEW



SECTION

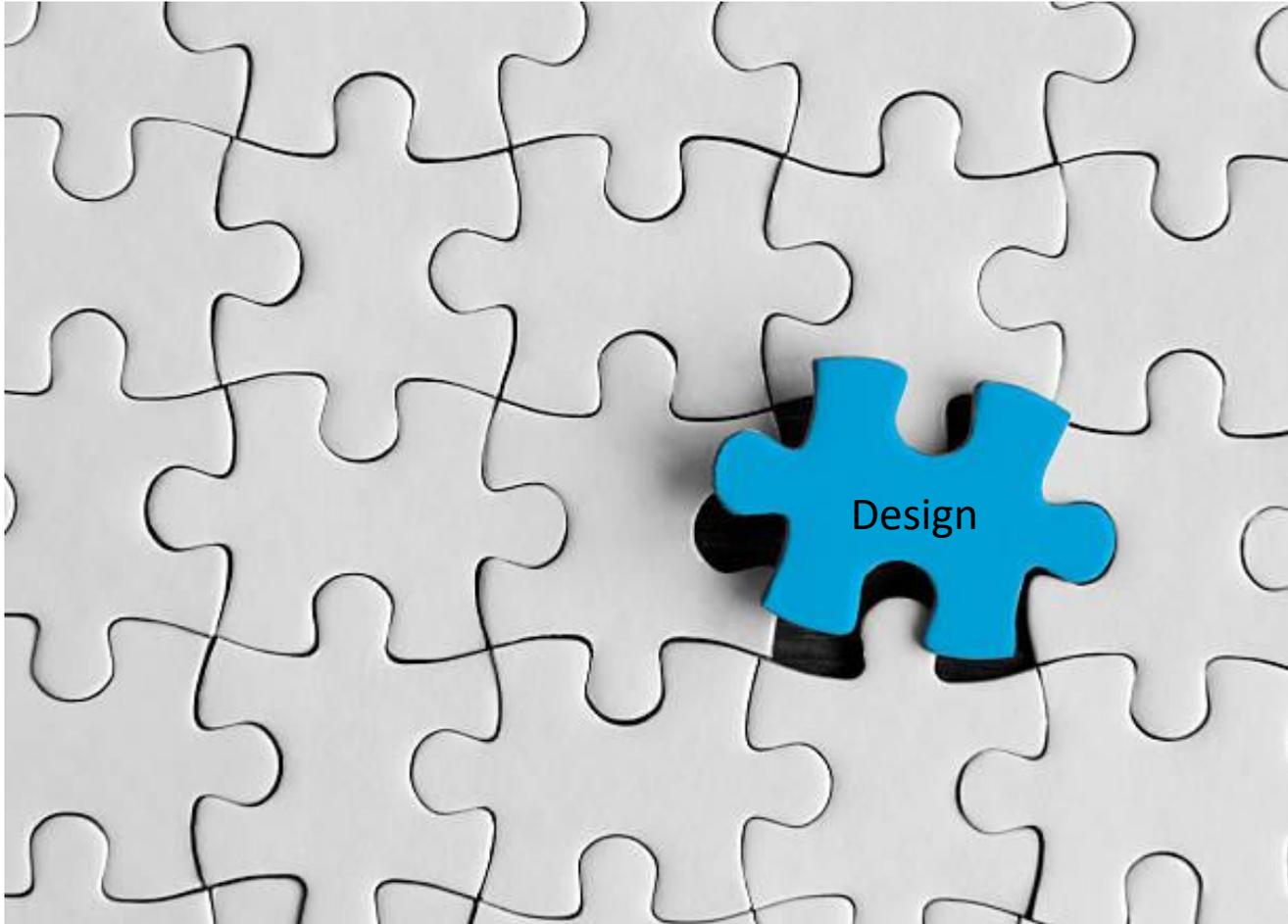
1 : 50

Optimise MiC module layout to avoid unnecessary structural walls

Use some open sided modules if needed



Possible Solutions



We need to collaborate

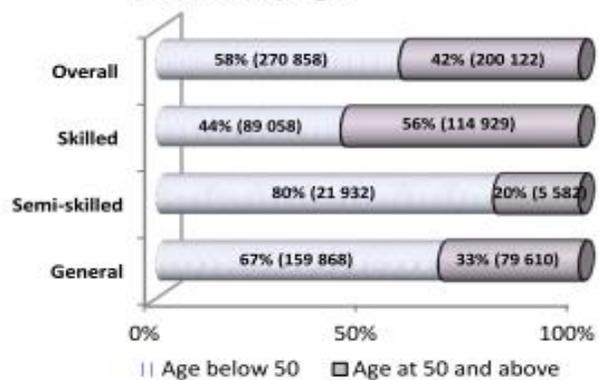
- Developers
- Government agencies
- Main contractors
- Precast specialists
- Logistic specialists
- M&E sub-contractors
- Site supervisors
- Othersetc



Our MiC Journey



Figure 6 – Percentage of registered construction workers by age



a significant journey
embark before too late
innovation and new ideas
walk together
expect obstacles
solve problems together
expect great sceneries
we will get there!



Thank You