PPVC - A DfMA Game-Changing Technology for Singapore

Prof. Chiew Sing Ping
SINGAPORE INSTITUTE OF TECHNOLOGY

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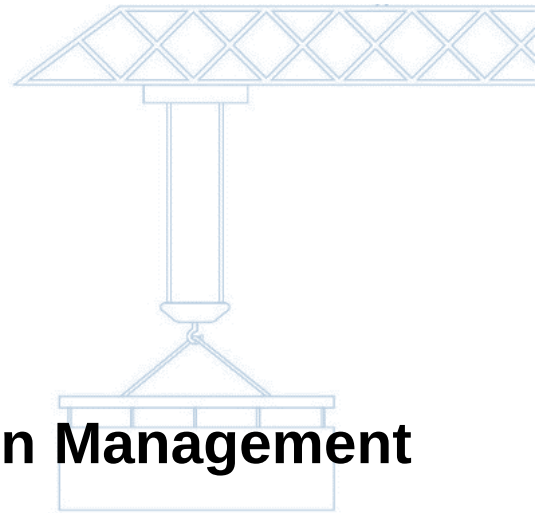

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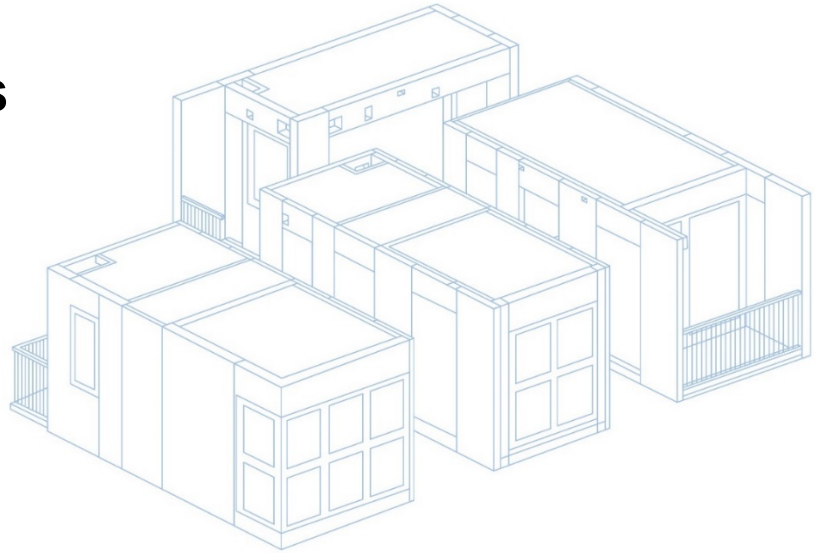


1. Introduction

1.1 Changing the Way we Build …

Design for manufacturing and assembly (DfMA)

- A key strategic thrust to raise construction productivity.
- Constructions are designed and detailed for a substantial portion of work to be done off-site in a controlled manufacturing environment.

Innovation Technologies… → Continuum of Technologies in STEEL-COMPOSITE STRUCTURES → …Game-Changing Technologies

Innovative Steel-Composite

PPVC

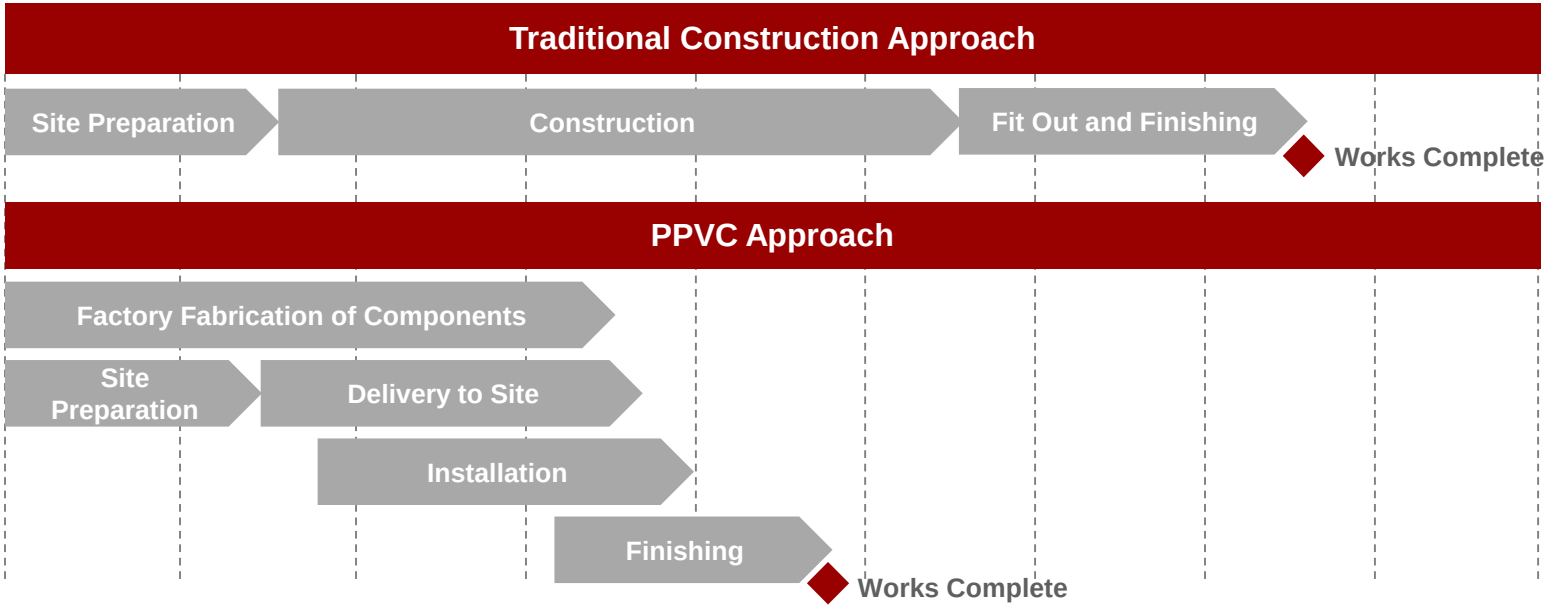
E.g. Multi-tier / pre-assembly steel components

E.g. Prefabricated Steel / Re-inforcement / Formwork

Steel
PPVC

1.2 Prefabricated Prefinished Volumetric Construction (PPVC)

- One of the game-changing technologies that support DfMA
- Complete modules made of multiple units with internal finishes, fixtures and fittings are manufactured in factories, and are then transport to site for installation in a lego-like manner.



1.3 Benefits of PPVC

- **Savings in construction time** up to about 15% - 20% from conventional construction.
- **Savings in manpower** up to about 25% - 40% from conventional construction. All the fabrication and assembly process are completed at off-site factory, thus reduces labour intensive construction activities.
- **Parallel on-site and off-site** construction concurrently.
- **Shorter floor cycle construction** from 14 - 21 days of conventional construction to approx. 4 days only for PPVC on site installation. **However longer preparation before construction.**
- **Higher consistency in quality and quality assurance** of building works in controlled factory fabrication and assembly environment.
- **Construction safety –** Minimize labour intensive works at height at construction site.
- **Environment** – Reduce noise and dust pollution on-site.
- **Sustainability** – Reusable steel material.

1.4 Types of PPVC Modules

Steel PPVC module

Hybrid PPVC module

Reinforced concrete PPVC module

	Weight	Handling and Transportation	Installation Method	Hoisting Machinery	Familiarity to Renovators in Maintenance, Replacement / Renovation Works	Fire Compartmentation / Rating	Provision for Barrier-Free Accessibility Requirements
Steel PPVC Module	15 tons - 20 tons	• Protection for completed modules • Permanent / temporary roof decking • May require temporary stiffening • Require lifting frame	Stacking method	Hoisting by crane	To include information of supplier manual	Compartmentation and use of materials shall comply with the applicable Code	Similar to conventional constructions

1.5 Building the Future

- Singapore have been actively applying PPVC technologies to achieve higher construction productivity
- Applications cover student hostel, hotel, condominium, HDB blocks, nursing home, office, etc..

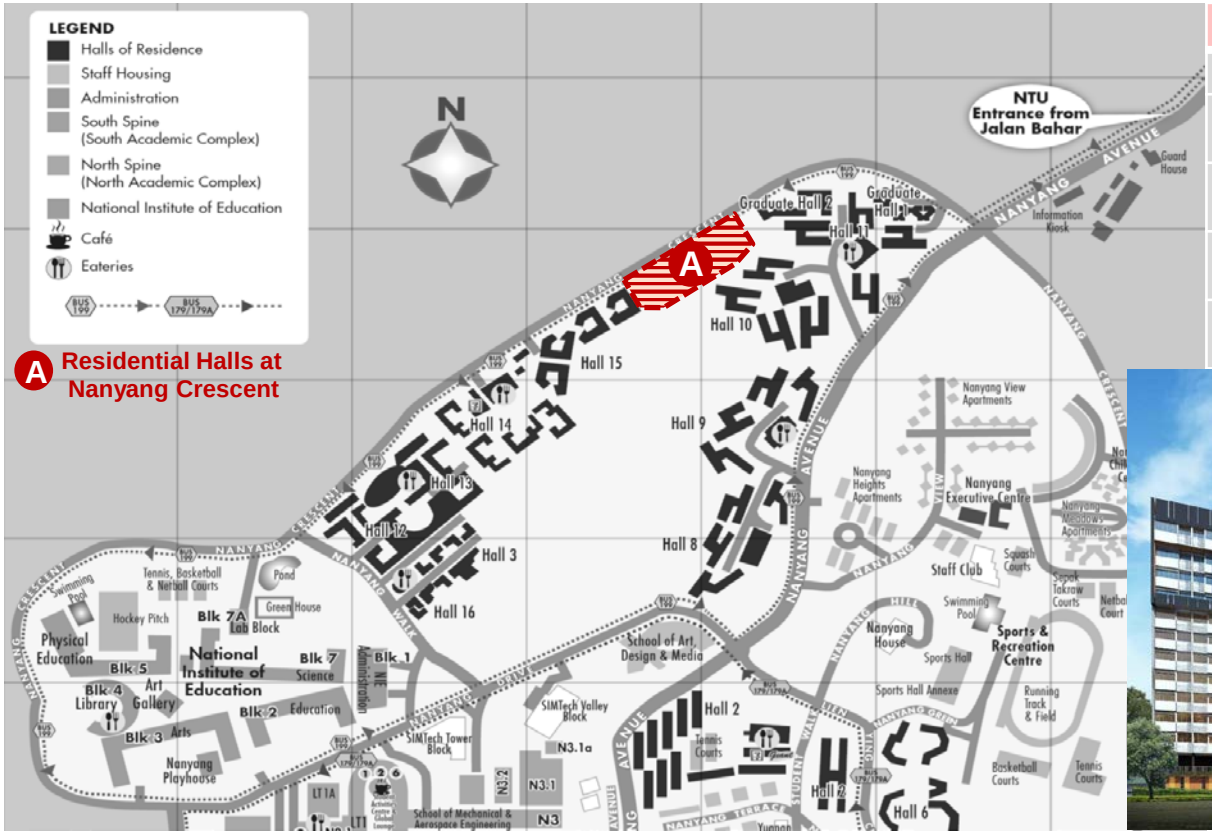
PPVC Projects in Singapore

Steel PPVC Project	Concrete PPVC Project	Hybrid PPVC Project	Others (Timber)
1. Nanyang Crescent Hostel 2. NTU North Hill Hostel 3. Crowne Plaza Hotel Extension 4. Wisteria at Yishun Avenue 4-Commercial and Condominium Development 5. TTJ new office building …	1. Brownstone Executive Condominium at Canberra Drive 2. Clement Canopy Condominium at Clementi Avenue 1 3. Park Colonial, Woodleigh 4. Garden Residences, Serangoon 5. Perumal Road 6. High Park Residences 7. Fernvale Glades, Sengkang 8. Northshore Edge, Punggol 9. Tampines Green Court 10. Valley Spring @ Yishun 11. West Terra @ Bukit Batok 12. JTC Space @ Tuas …	1.Woodlands Nursing Home	1. JTC LaunchPad @ One-north

2. Key Design Considerations

Case Study – Student Hostel

Nanyang Crescent Hostel, Nanyang Technological University, Singapore (1BLK of 11-Storey & 3 BLKS of 13-Storey Student Hostel Development & 1 BLK of 4-Storey MSCP)



Development Summary	
Gross Floor Areas	48,550 ㎡
No. of single occupancy rooms	1233 (1233 students)
No. of double occupancy rooms	294 (588 students)
No. of staff occupancy rooms	12 apartments for Faculty-in-Residence
Expected TOP	2ND Quarter 2017 (24 months contract)

Source: Santarli-Zheng Keng JV Main Contractor



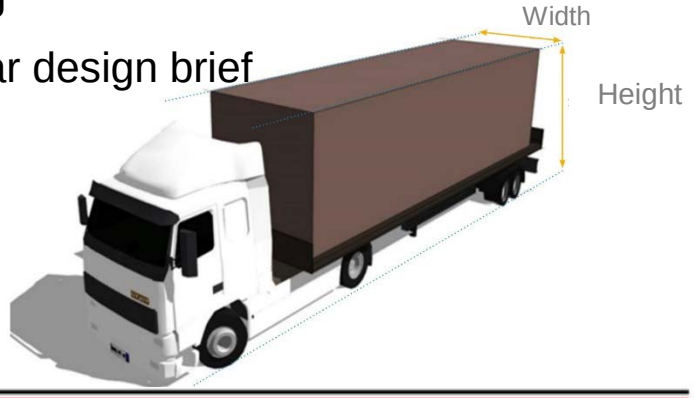
View from Living Street

View of Single Occupancy Bedroom with Bathroom

View of Double Occupancy Bedroom

2.1 Design consideration for PPVC concept

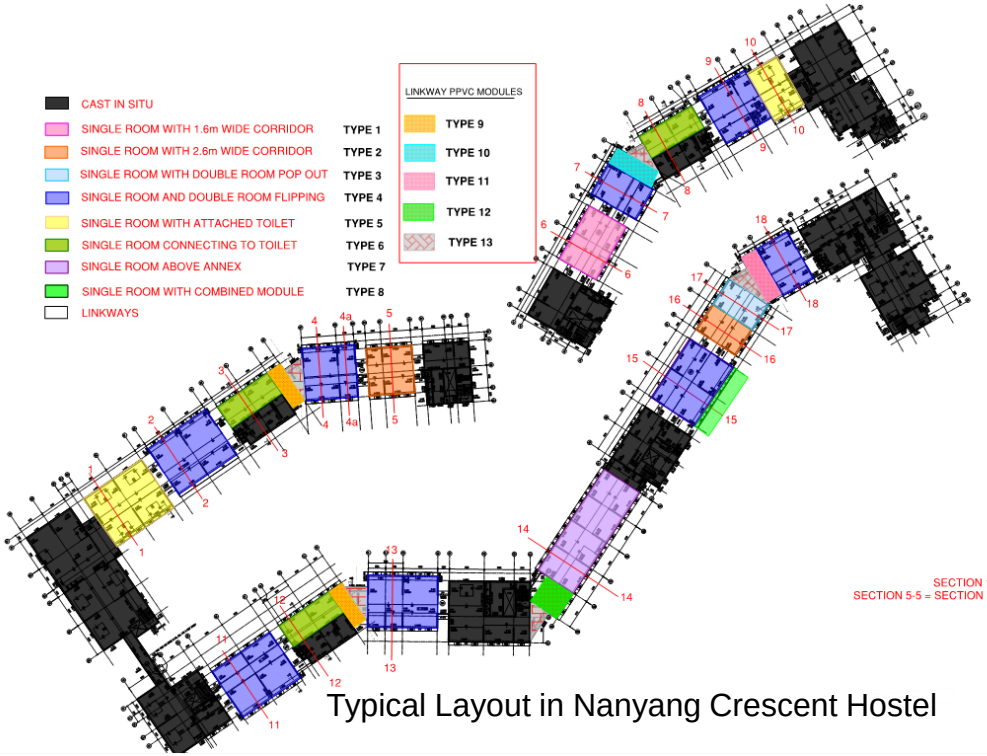
- Modularity
- High repetition, low variation in types
- Façade details to be within box height and light weight
- Box height < 4.5m (inclusive of truck height), width ≤ 3.4m, laden Weight < 80 tons by LTA.
- Heavy loads such as: water tanks on roof top swimming pool; environmental decks with / without plants maintenance gantry; other heavy usage
- RC areas still required for escape staircases, M&E services risers, refuse chute, M&E rooms, lift core, overall building stability
- Construction sequence; aviation height limits
- M&E services placement; sanitary FT/FW discharge pipes
- Built-in furniture – strengthening of walls and ceiling
- Employer / Consultants – know what you want, clear design brief
- **Industry mindset change**



2.2 Early incorporation of Modular system - Suitable for highly repetitive floor plate

2.2.1 Modularization

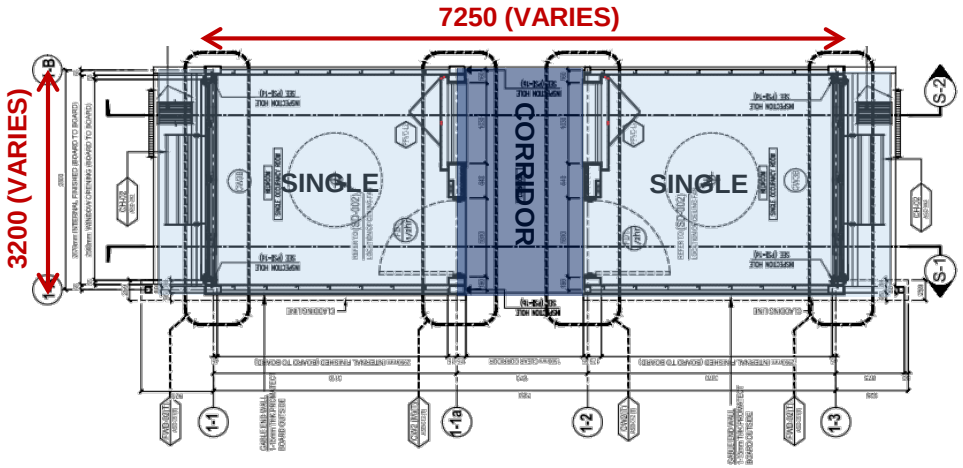
- The modularization is largely affected by the room dimensions, column locations, stiffener locations, wall types and cross bracing.
- At the unit layout planning and design stage, the PPVC modularization must be undertaken in tandem with the unit layout design as early as possible.

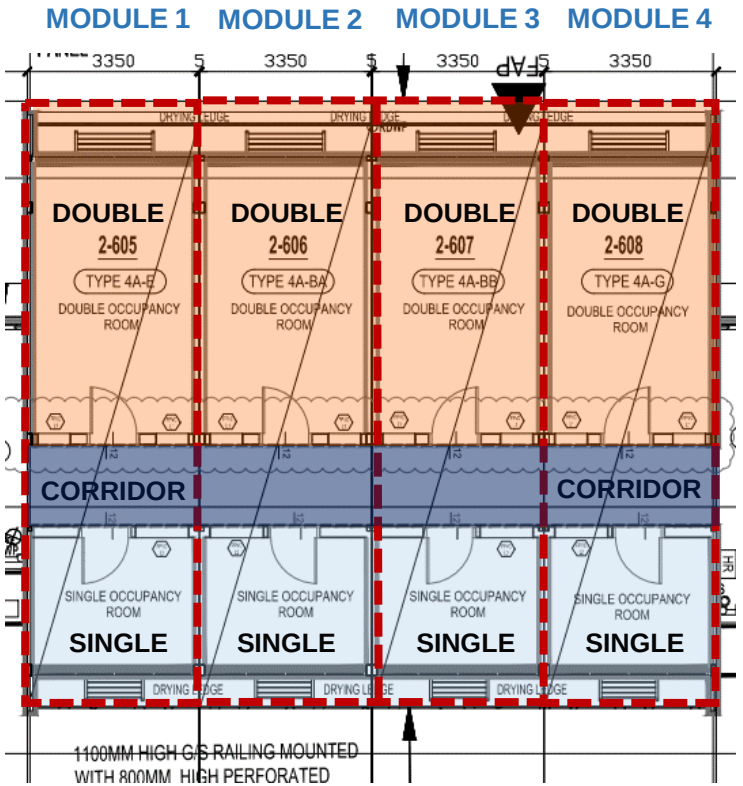


Typical Layout in Nanyang Crescent Hostel

2.2.2 Dimension on Plan

- To ensure the layout plan design comply with regulatory requirements.
- To ensure the size of modules allow transportation from factory to site.



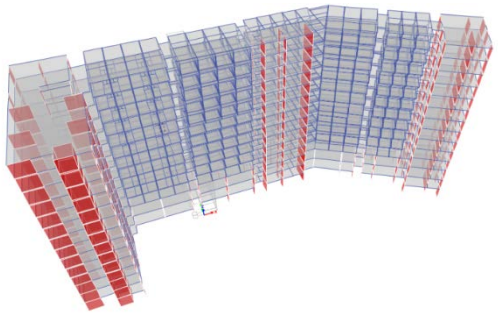


Overall Floor thickness: approx. 395 mm
Overall Wall thickness: approx. 235 mm

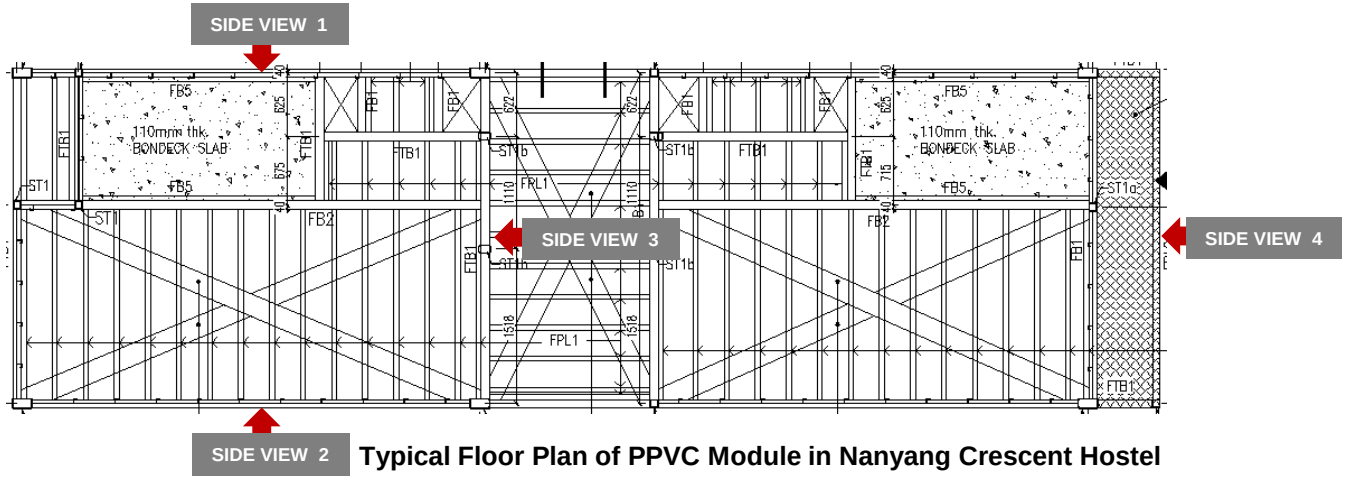
2.3 Structural Design Consideration

2.3.1 Structural Modelling

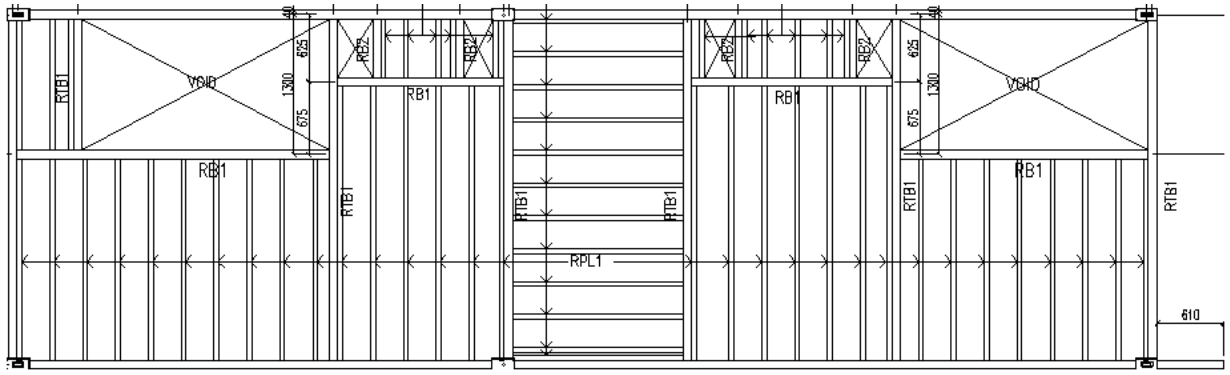
3D modelling of building structural shall be carried out using suitable computer analysis software.



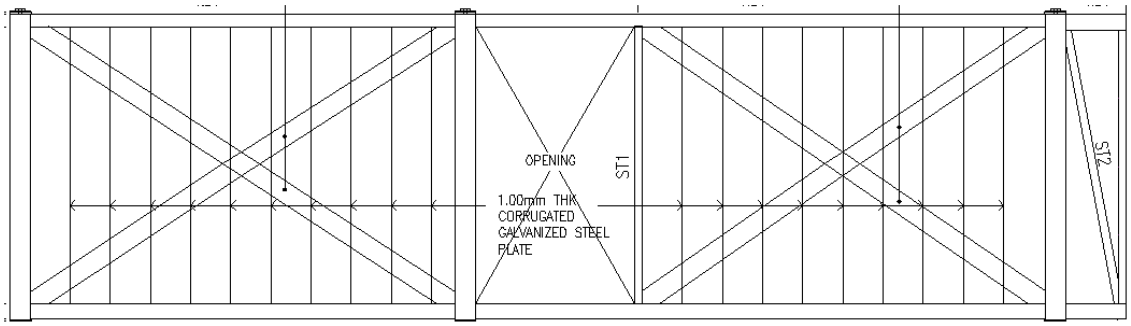
Vertical and Lateral Load Analysis



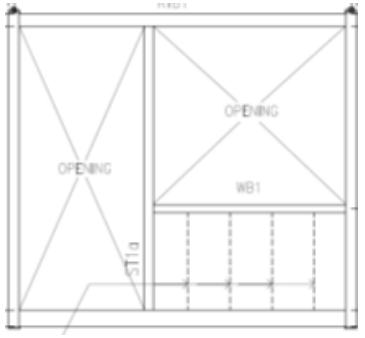
Typical Floor Plan of PPVC Module in Nanyang Crescent Hostel



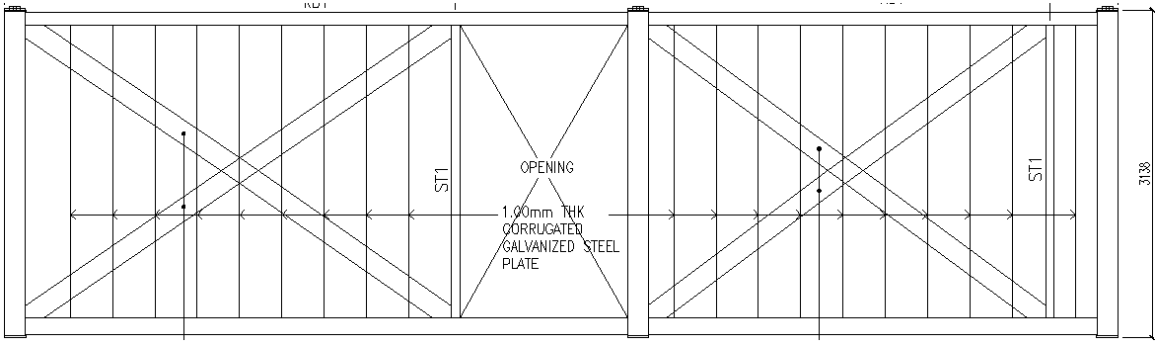
Typical Roof Plan of PPVC Module in Nanyang Crescent Hostel



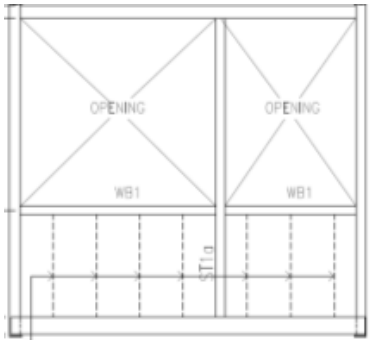
SIDE VIEW 1



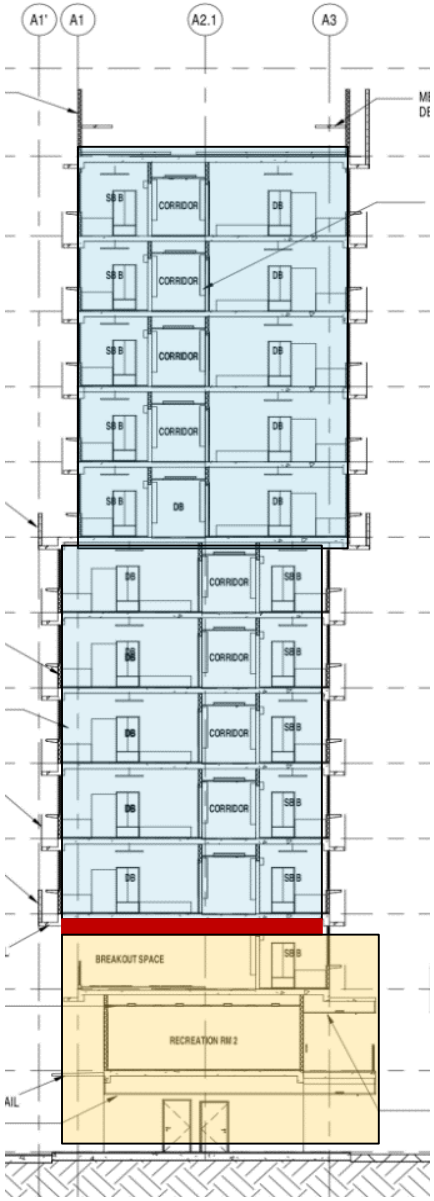
SIDE VIEW 3

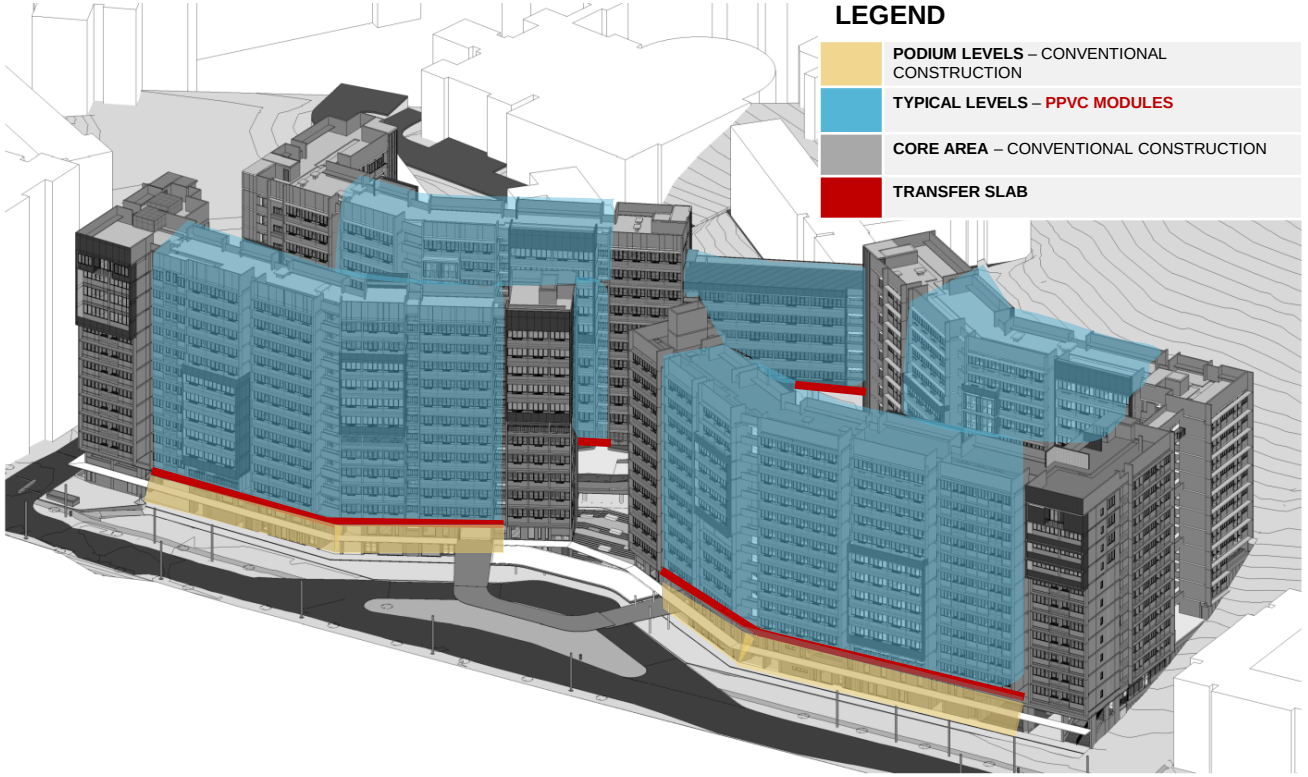


SIDE VIEW 2



SIDE VIEW 4

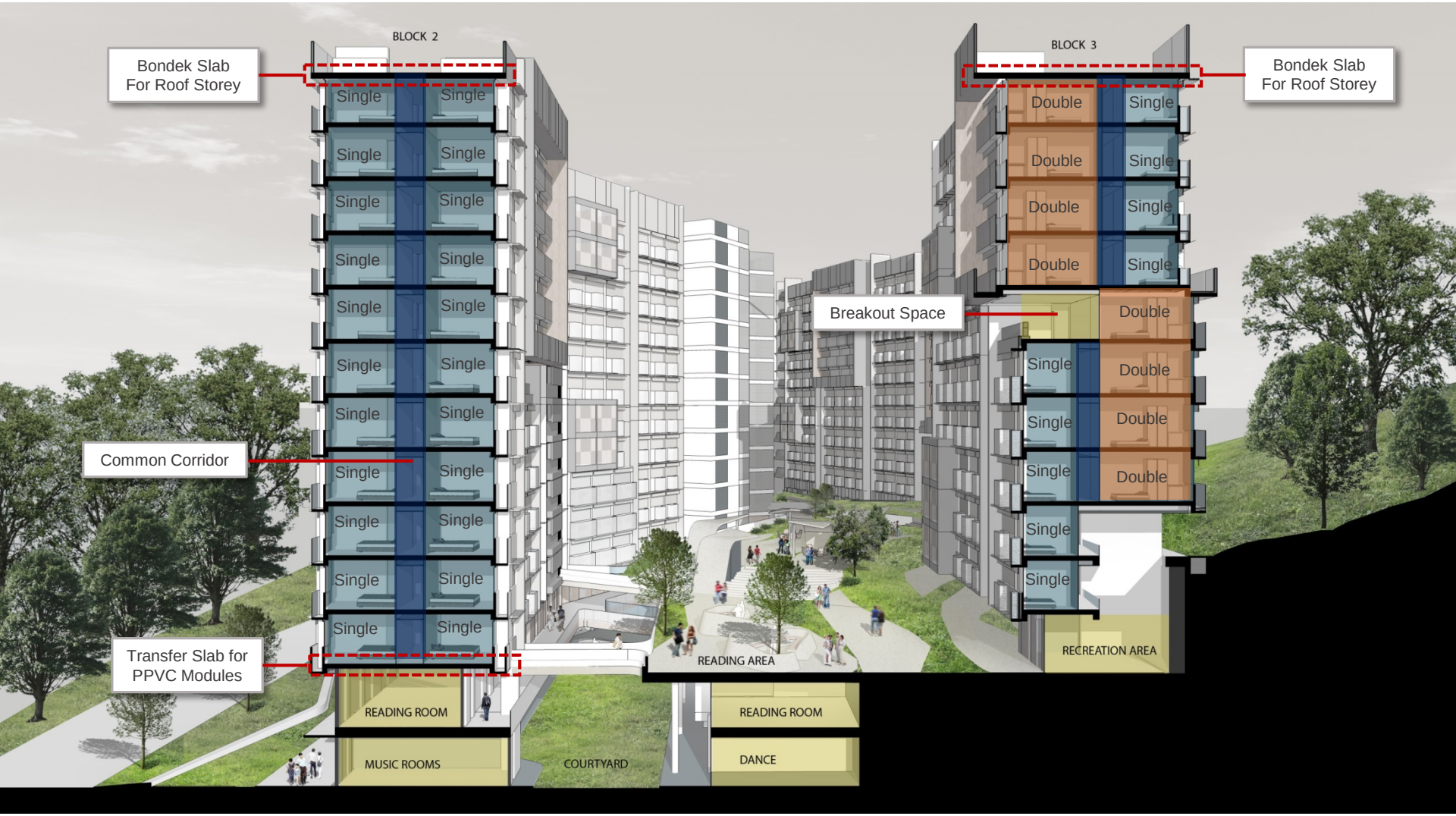




PPVC Design Integration with Conventional Construction

- Conventional construction of podium floors to handle sloping terrain at site.
- Transfer slab between conventional construction and PPVC (steel-type modules) .
- Centralized conventional construction services and circulation cores for lateral stability of PPVC.

- **Section Thru Site**



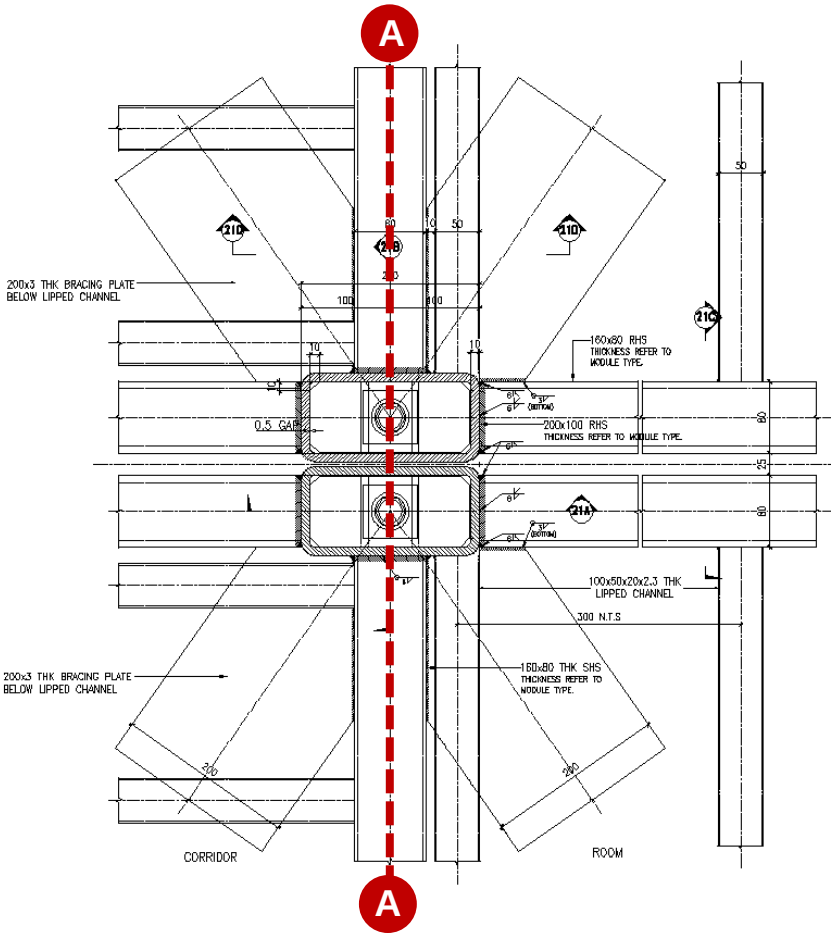
2.3.2 Vertical Modules Connection

- The vertical modules connection is crucial for the structural behavior especially for high rise buildings.
- Vertical joints are to be designed for eccentricity or imperfection in accordance with the Building Code Requirement.

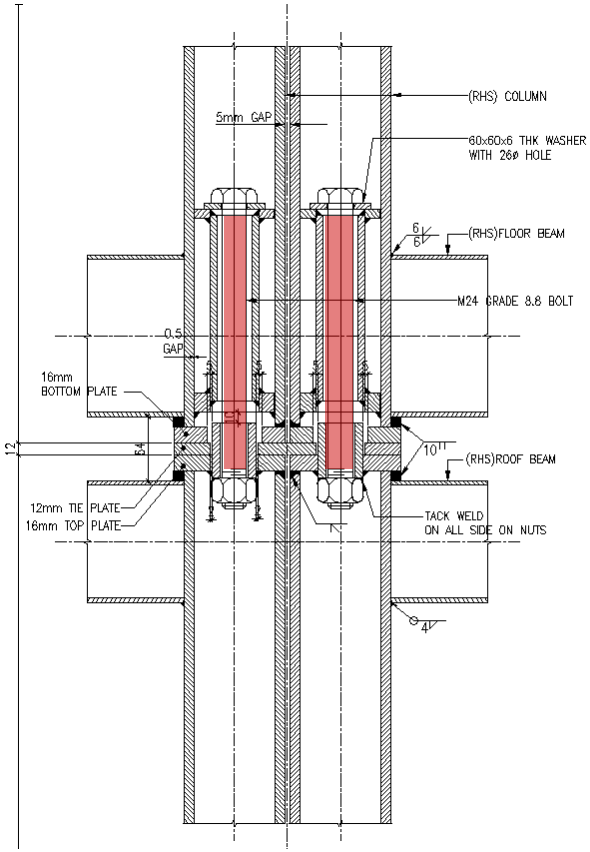
2.3.3 Horizontal Modules Connection

- The horizontal modules connection forming the floor diaphragm, are contribute to the overall building stiffness.
- The peripheral ties and internal ties shall be provided as per the Building Code Requirement.
- A classic example for steel PPVC module joints is the bolting system.

- **Typical Internal Column Connection in Nanyang Crescent Hostel**



PLAN

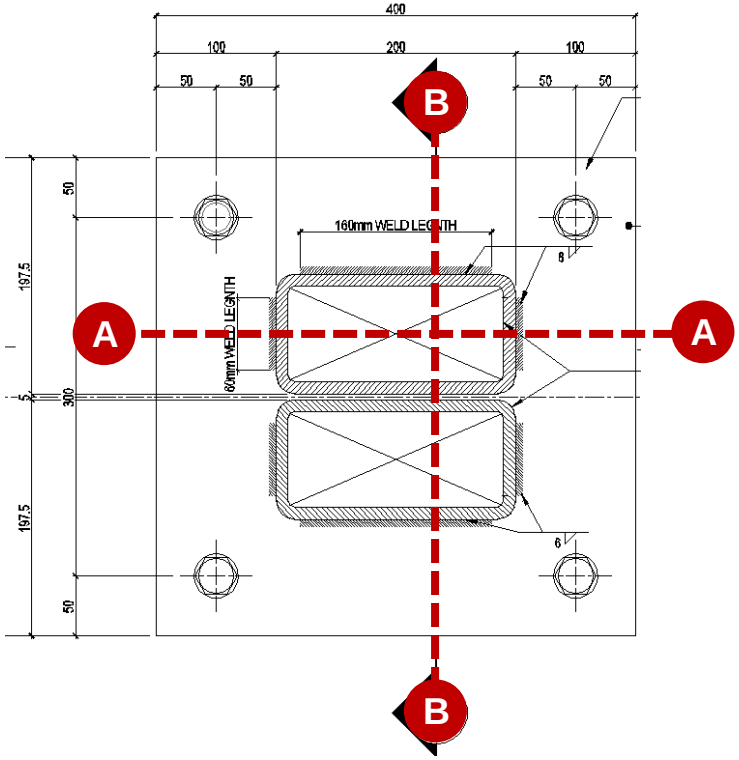


Upper Module

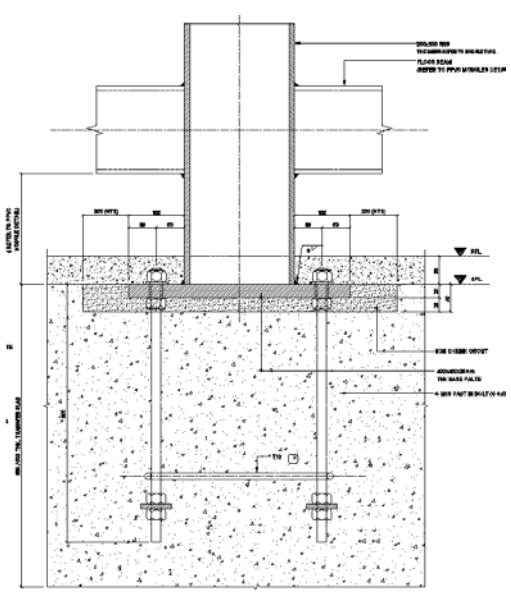
Lower Module

SECTION A-A
(CONNECTION JOINT)

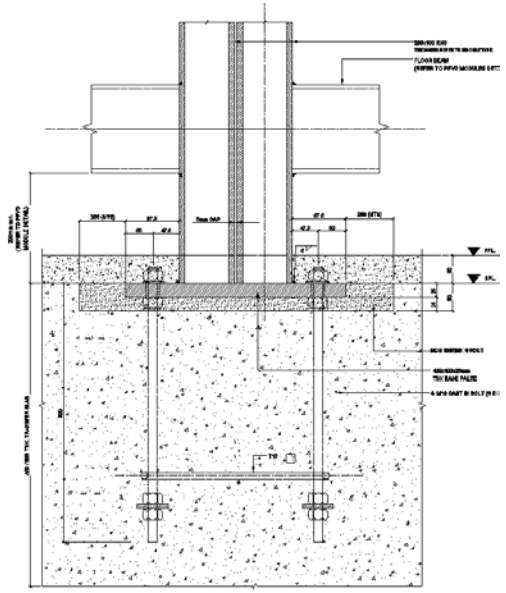
- **Column Connection Details at Transfer Slab**



PLAN



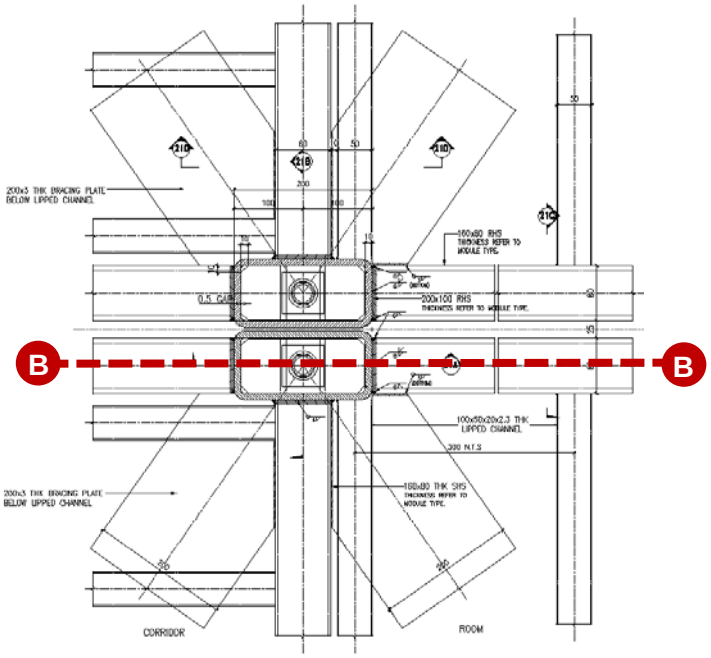
SECTION A-A



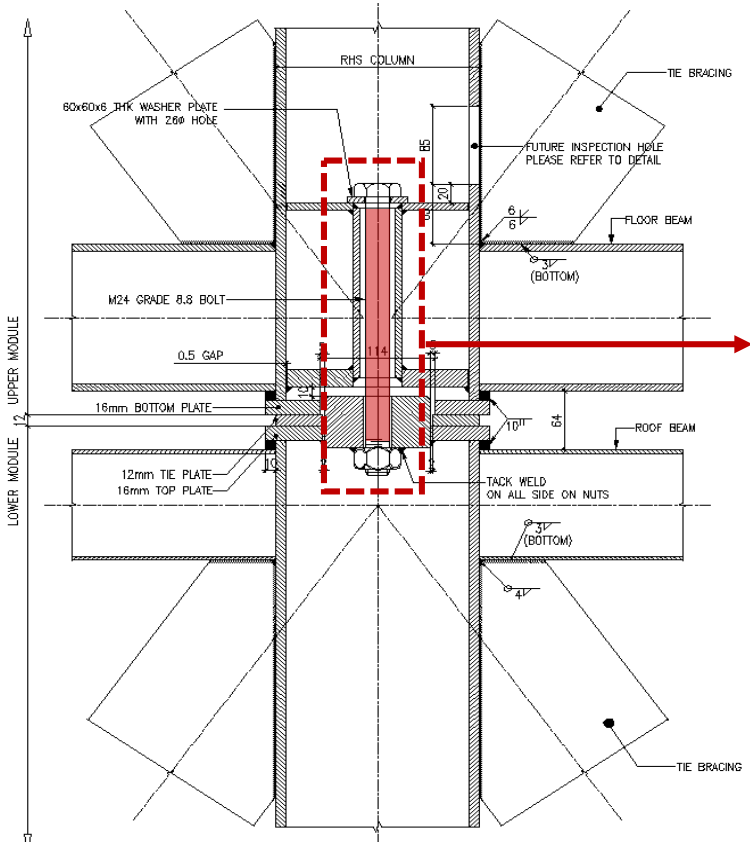
SECTION B-B

- **Connection Bolt in Nanyang Crescent Hostel**

Function : To resist the tension force during accidental scenarios.

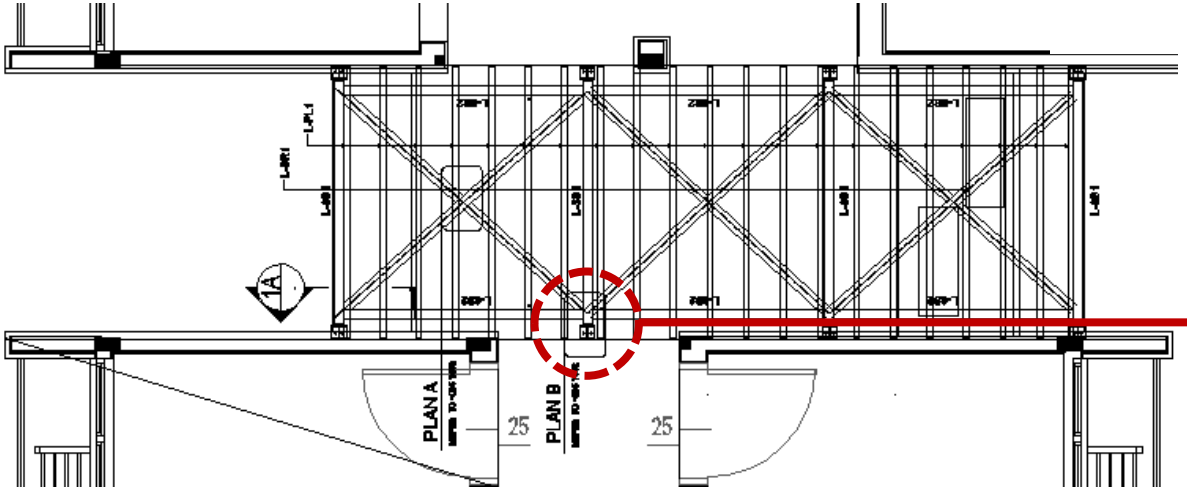


PLAN

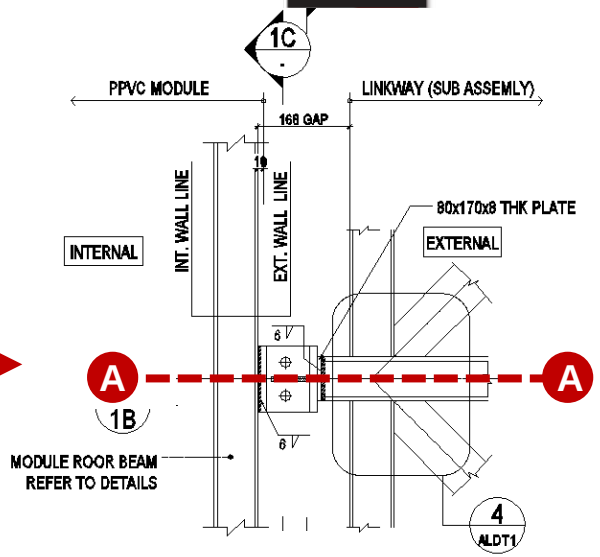


SECTION B-B

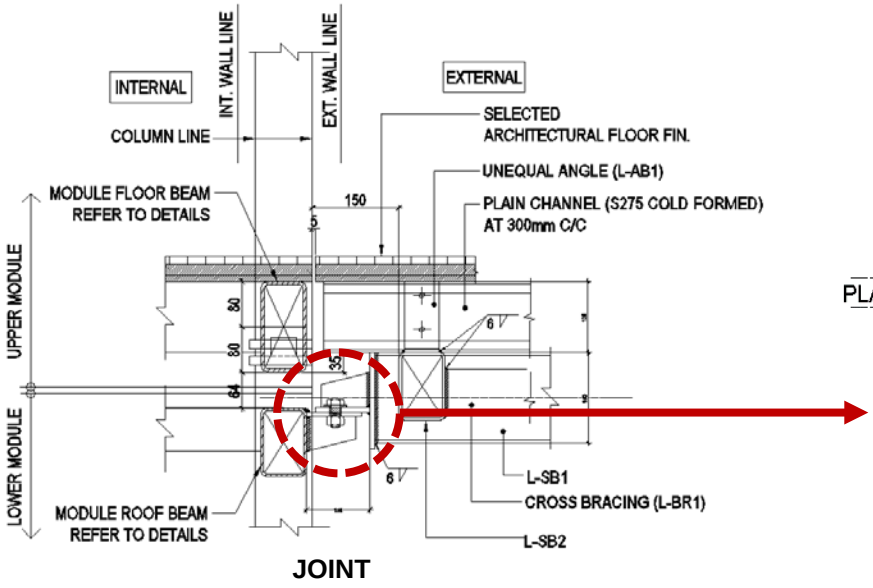
- **Connection Between Link-way and PPVC Module**



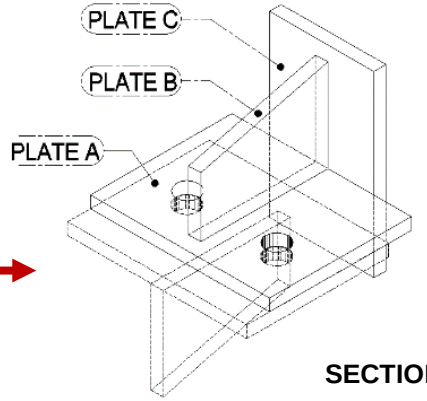
PLAN



JOINT PLAN

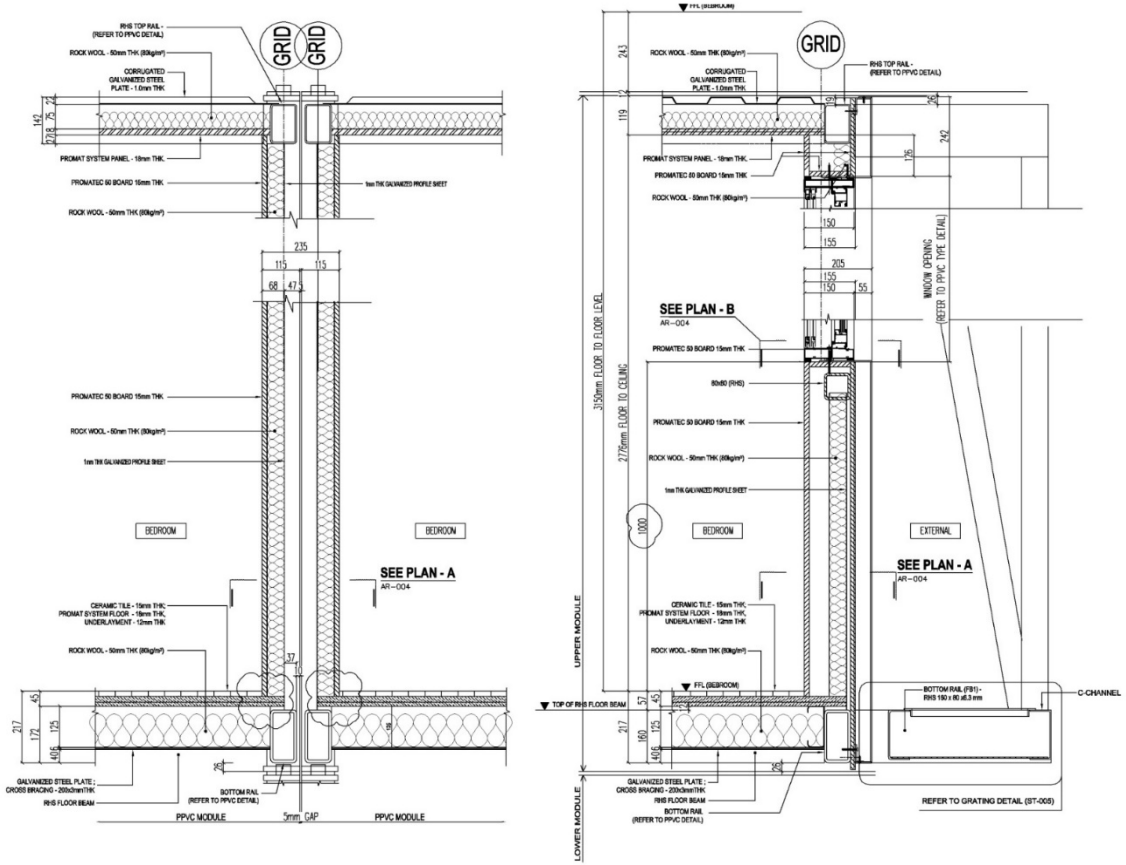


JOINT

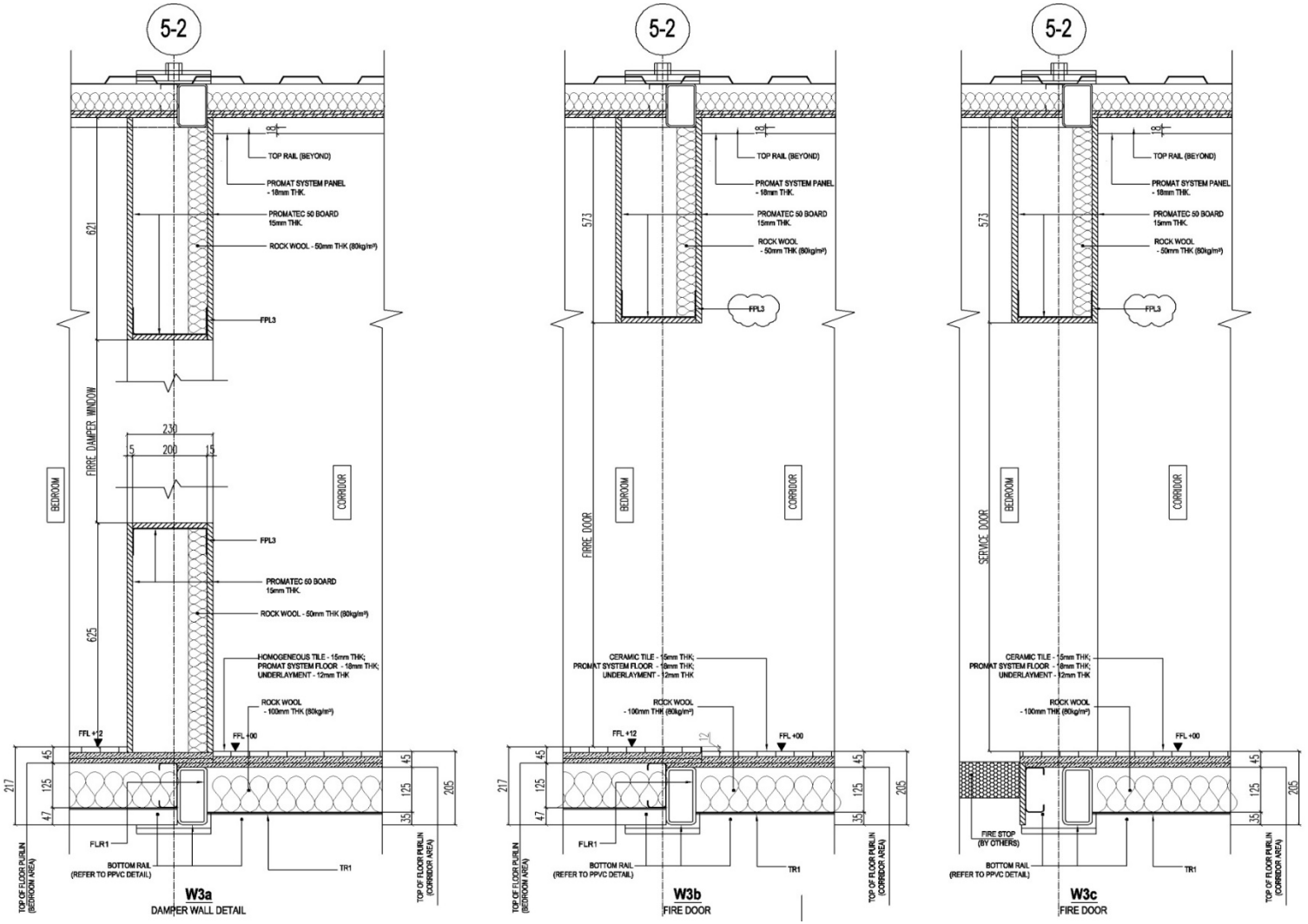


SECTION A-A

- **External Wall**

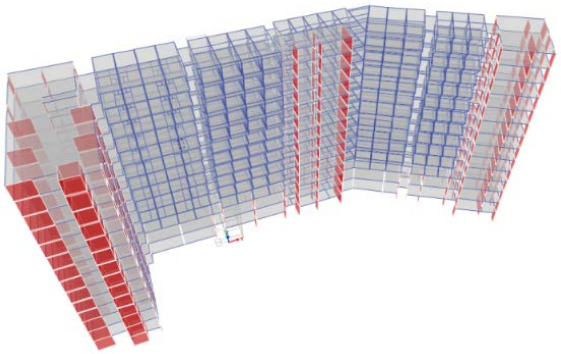


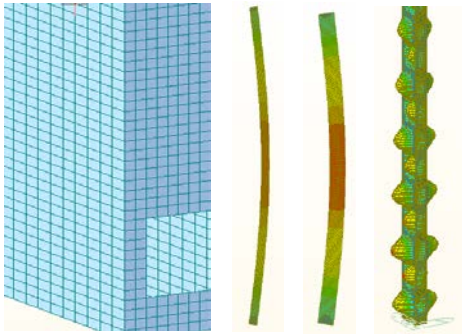
- **Fire Damper Wall**

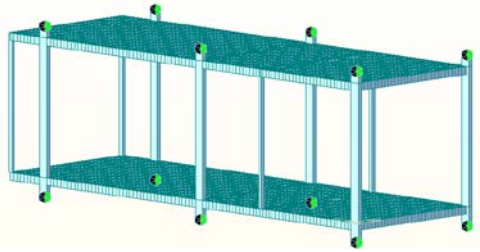


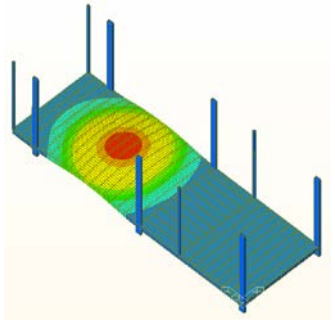
2.4 Structural Analysis

3D Modelling









Design of Structural Members:

column design

- effective length should be carefully determined

bracing design

- buckles under compression, non - linear analysis

beam & purlin design

- take effective methods to resist lateral torsional buckling

Column Buckling Behavior Study:

Conclusion:

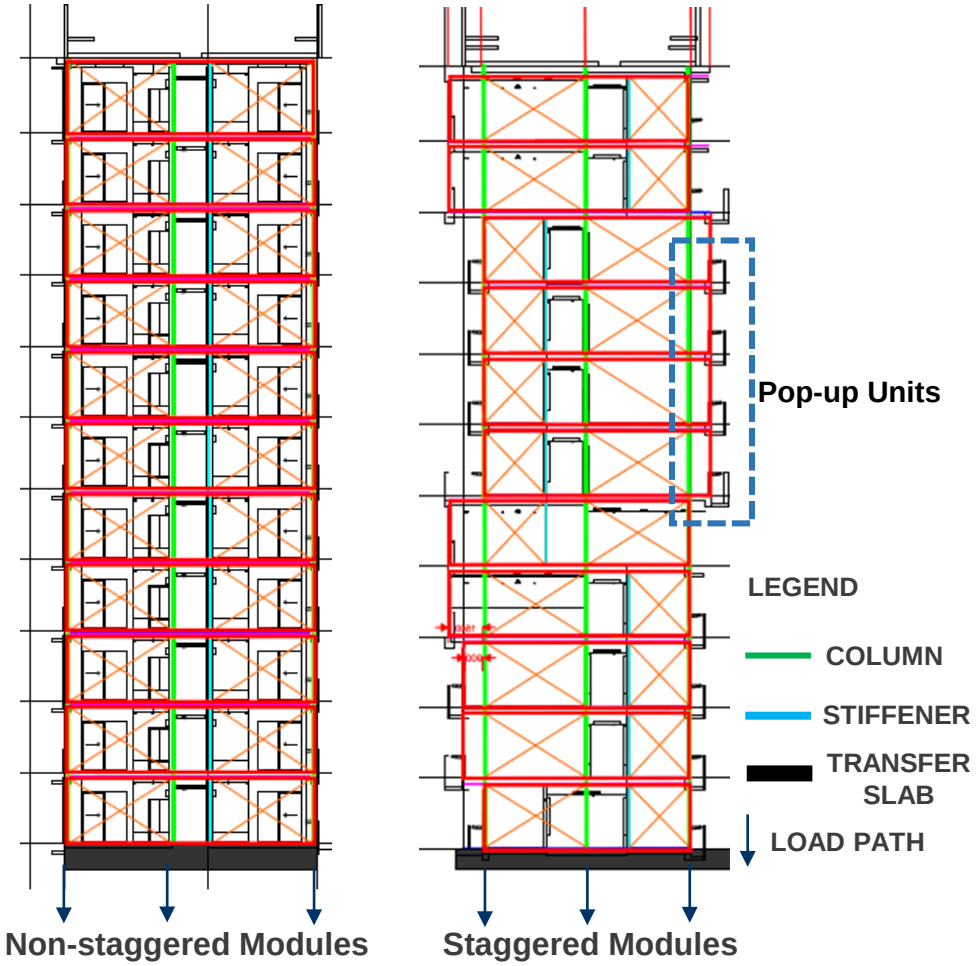
Side opening at the bottom of column will NOT have a significant impact on the column's buckling capacity.

Vibration Check:

Conclusion:

The floor vibration frequency satisfies the limit recommended by code of practice.

2.4.1 Standardization of Modules



Vibration Period and Frequencies

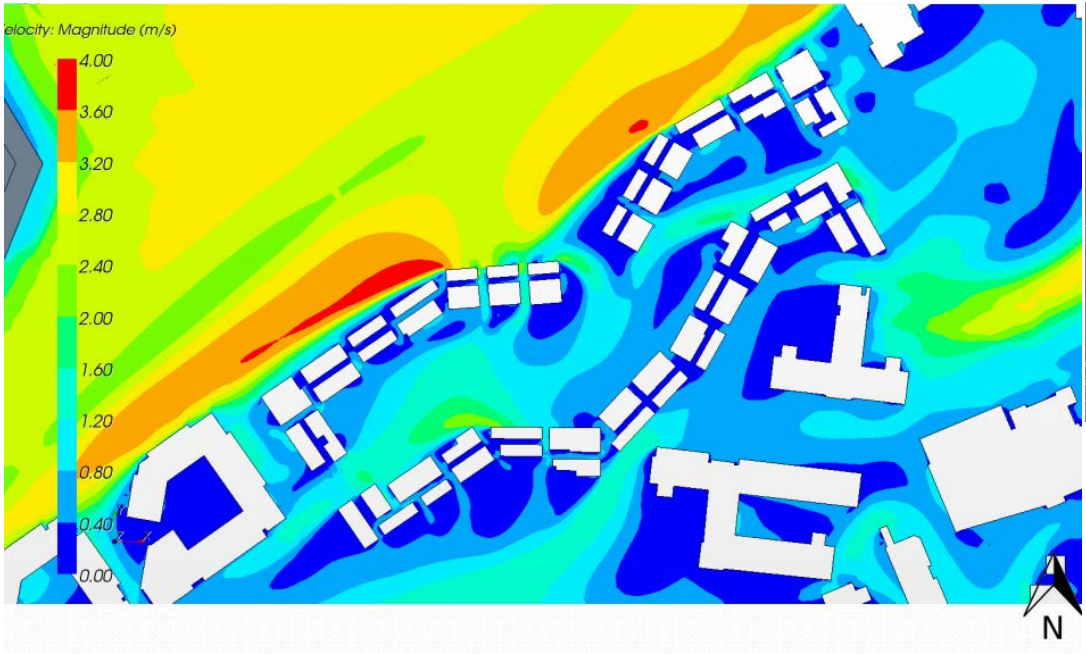
Mode	Period(s)	Frequency(Hz)
1st	0.110	9.10
2nd	0.078	12.79
3rd	0.065	15.44
4th	0.058	17.40
5th	0.055	18.18
6th	0.054	18.32

Natural Frequency > 5Hz

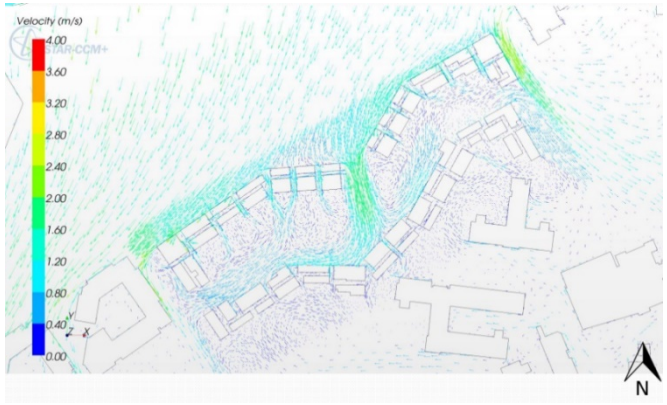
Satisfied

Standardized the modules will improve the fabrication efficiency and cost savings through economy of scale.

2.4.2 CFD Studies



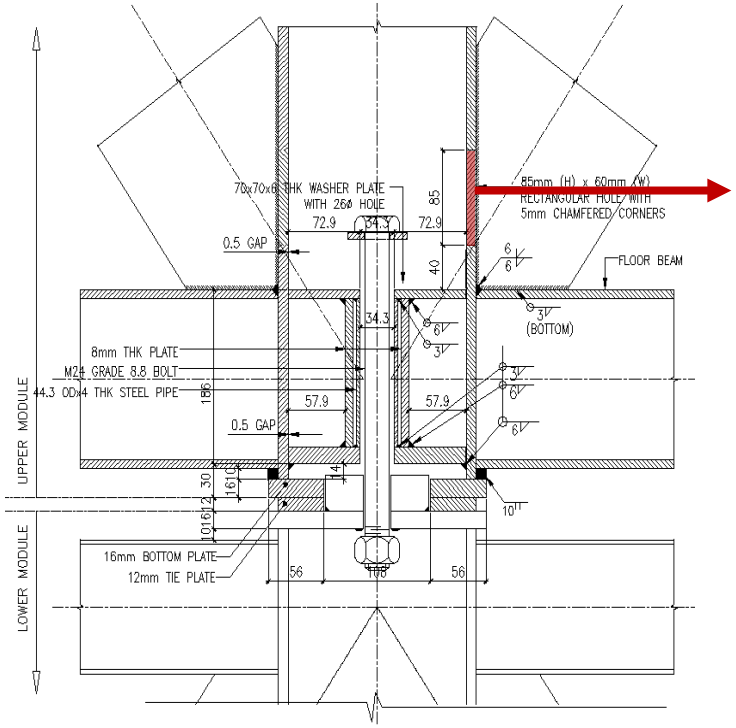
Macro & Micro Level Natural Ventilation Simulations Conducted on Massing Model



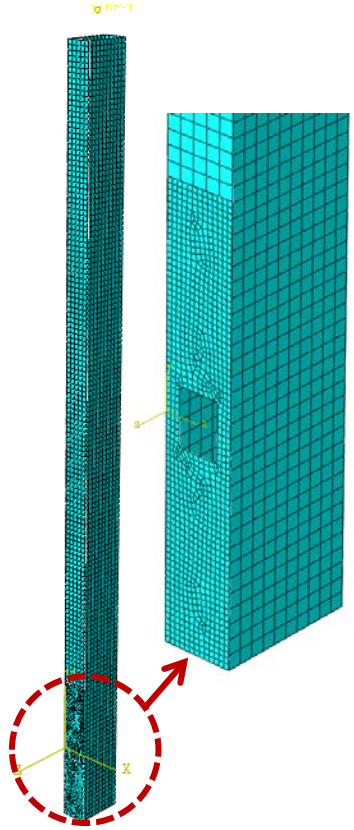
2.4.3 Structural Robustness

Provisions for structural robustness involve providing effective horizontal and vertical ties, national removal of one column / nominal section of wall or designing such elements as a “key element” or systematic risk assessment in accordance with the building’s Categorization of Consequences Classes as per relevant EN 1991- 1-7 provisions.

- **Effect of Side Opening**

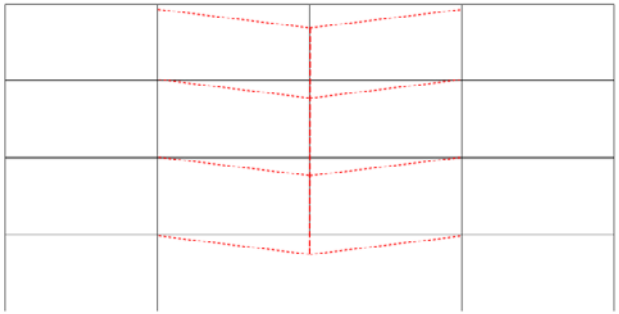


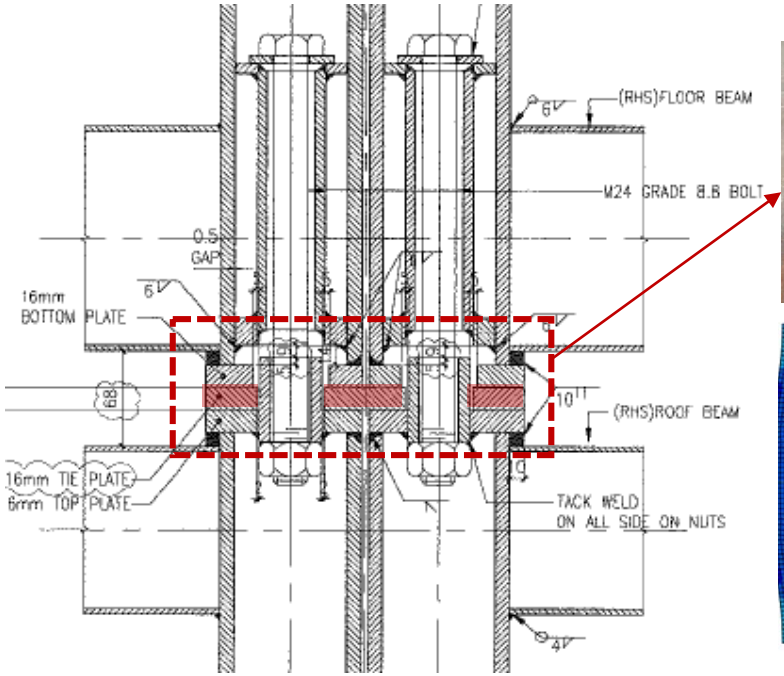
SECTION

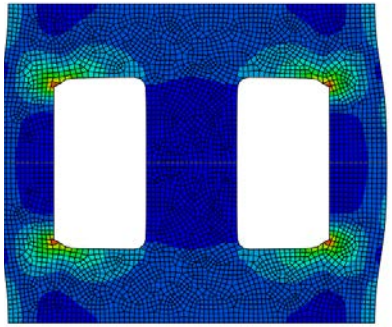


- **Tie Plate**

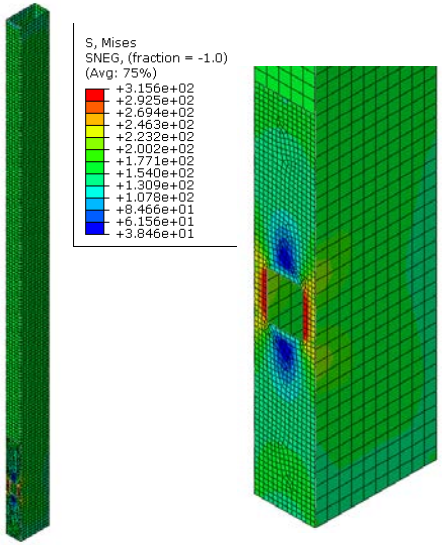
Tie Plate is able to develop catenary action under accidental removal of bottom columns.





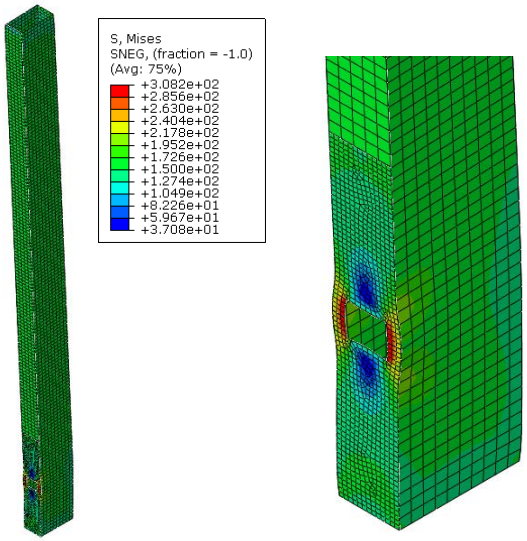


2.4.4 Stress Concentration Analysis



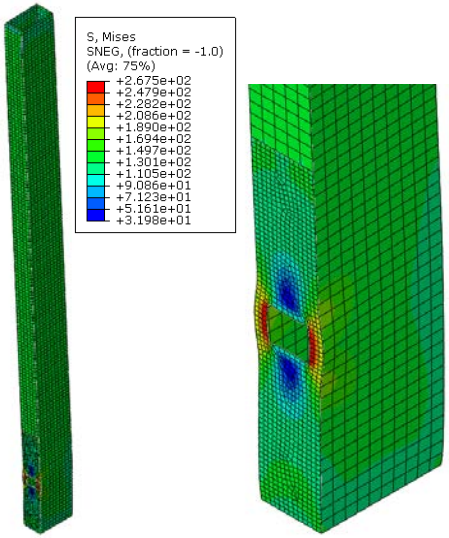
Maximum Mises stress : 315 N/mm^2 < Yield stress 355 N/mm^2

Case 1 Column Size: RHS 200 x 100 x 12.5mm, Maximum Axial Force: 1171 KN



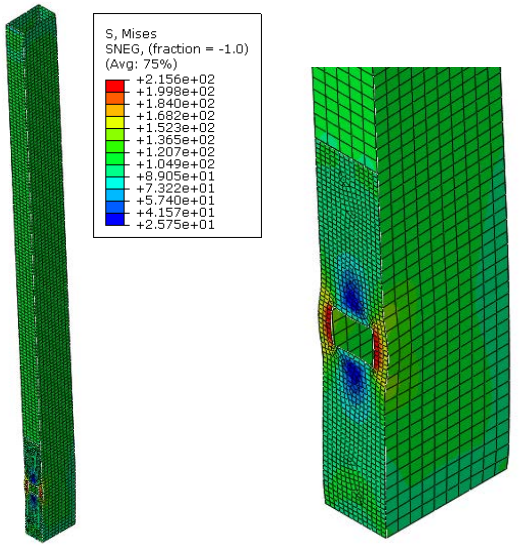
Maximum Mises stress : 308 N/mm2 < Yield stress 355 N/mm2

Case 2 Column Size: RHS 200 x 100 x 10mm, Maximum Axial Force: 910 KN



Maximum Mises stress : 268N/mm2 < Yield stress 355 N/mm2

Case 3 Column Size: RHS 200 x 100 x 8mm, Maximum Axial Force: 625 KN

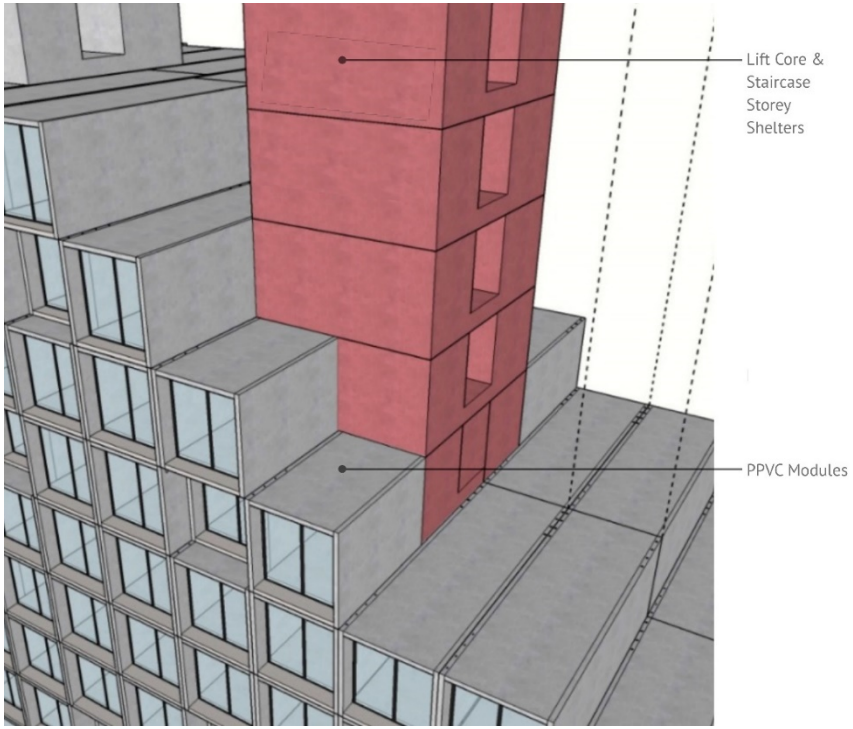


Maximum Mises stress : 216N/mm2 < Yield stress 355 N/mm2

Case 4 Column Size: RHS 200 x 100 x 6.3mm, Maximum Axial Force: 373 KN

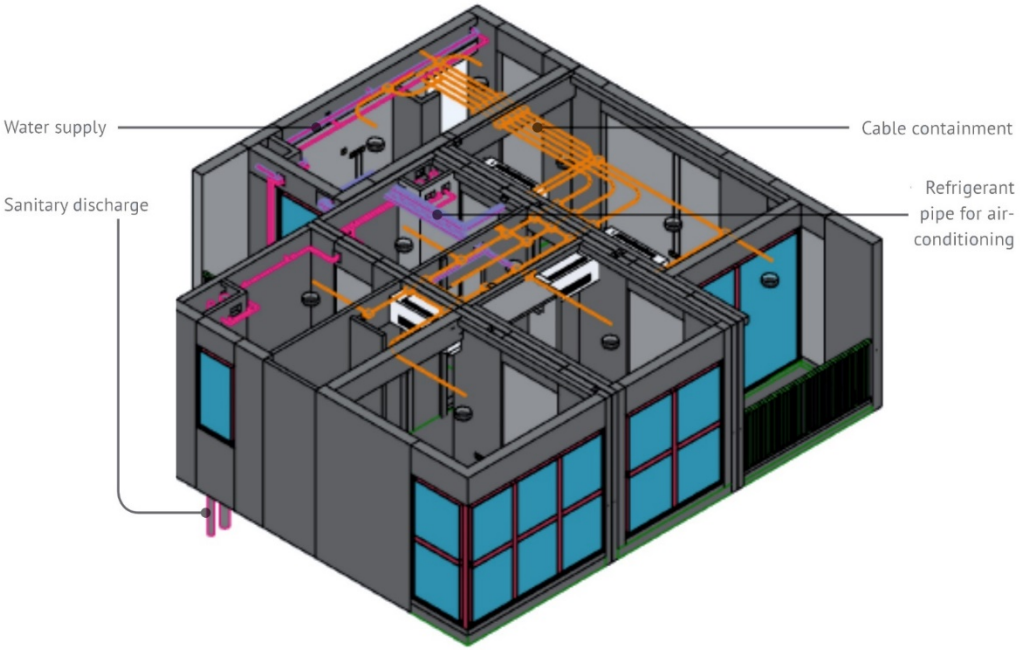
2.4.5 Modules Connection to Civil Defense Shelter Wall

The connection details should take into account the construction sequence of shelter wall, launching of precast staircase flights (for SSS), casting of shelter floor slab and installation of abutting PPVC modules, hollow cores formed in the precast hollow core shelter walls, as well as the installation of steel reinforcement cages inside the hollow cores at site.

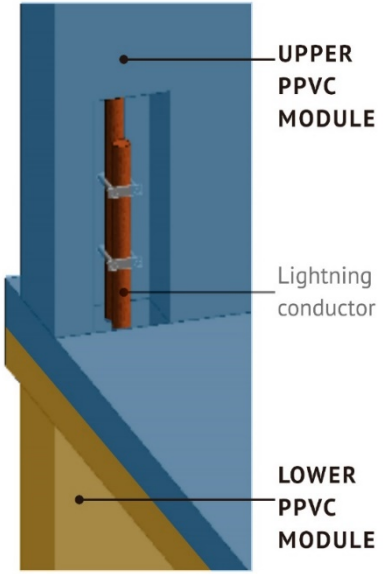


2.5 Mechanical, Electrical and Pluming (MEP) Design Consideration

- Electrical, Water supply, Sanitary, Air-conditioning and Mechanical Ventilation, Gas

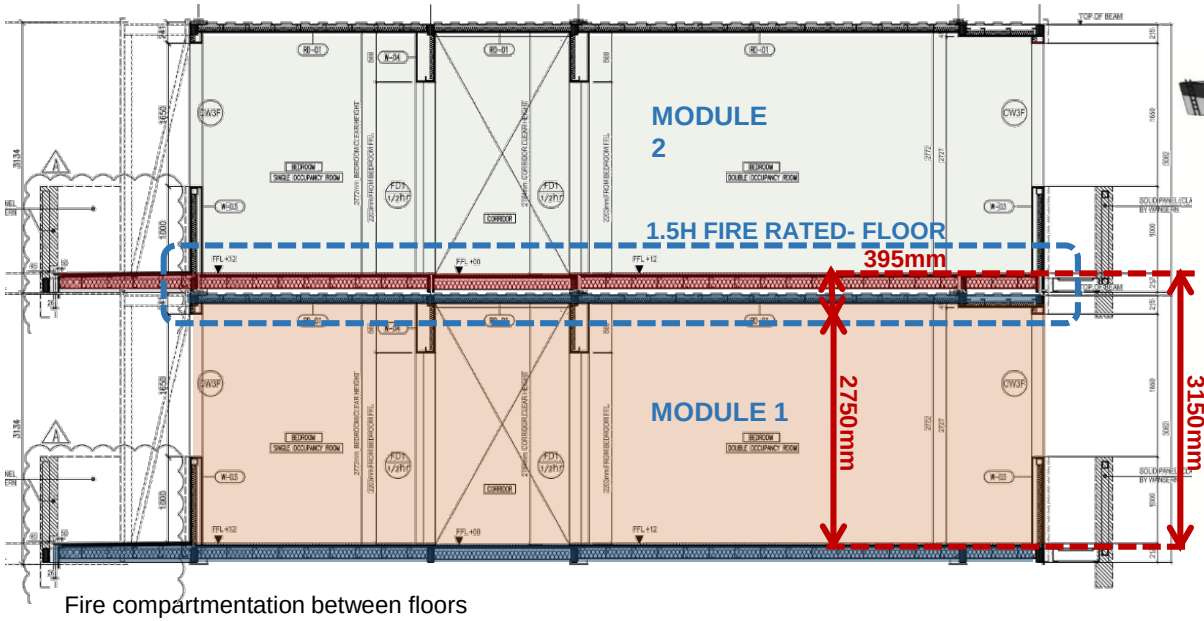


- Lightning Protection

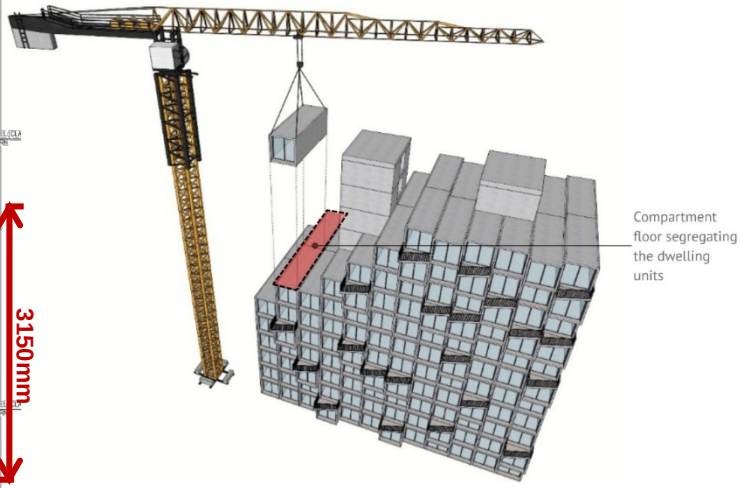


2.6 Compliance of Fire Compartmentation

- The typical compartment floor between floor levels shall comply with the required fire resistance rating in accordance with the Fire Code requirements.
- The compartment walls segregating the dwelling units as well as segregating the dwelling units and fire fighting lobby shall comply with the required fire resistance rating in accordance with the Fire Code requirements.

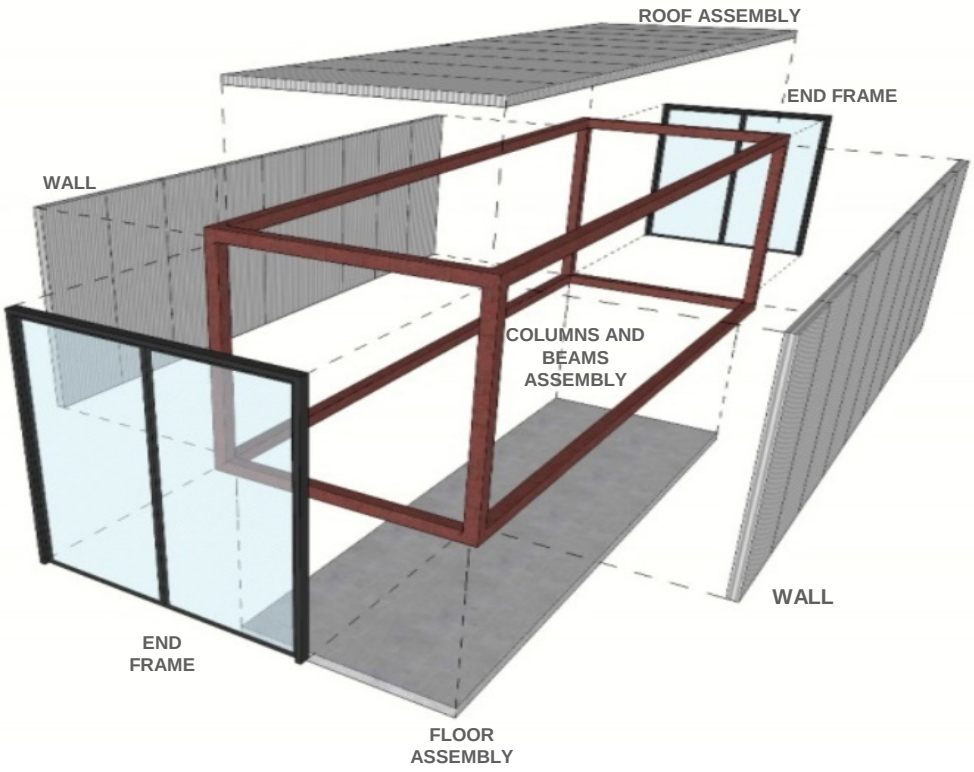


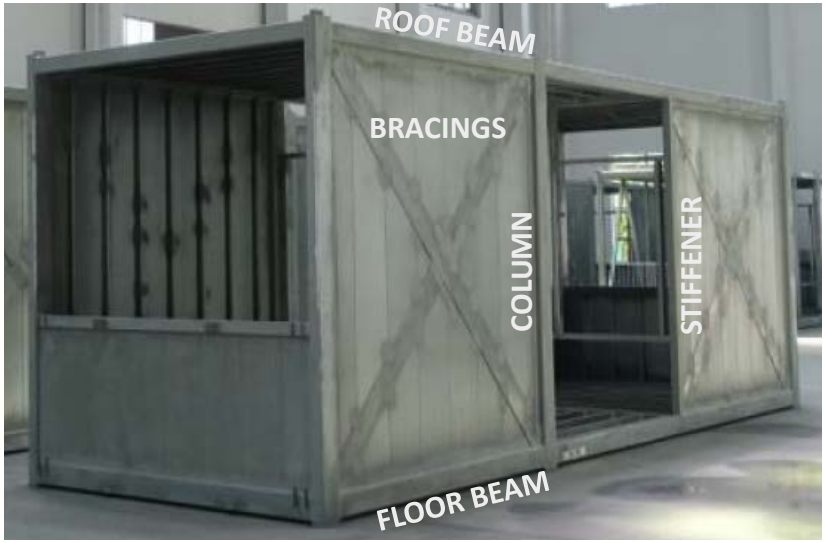
Fire compartmentation between floors



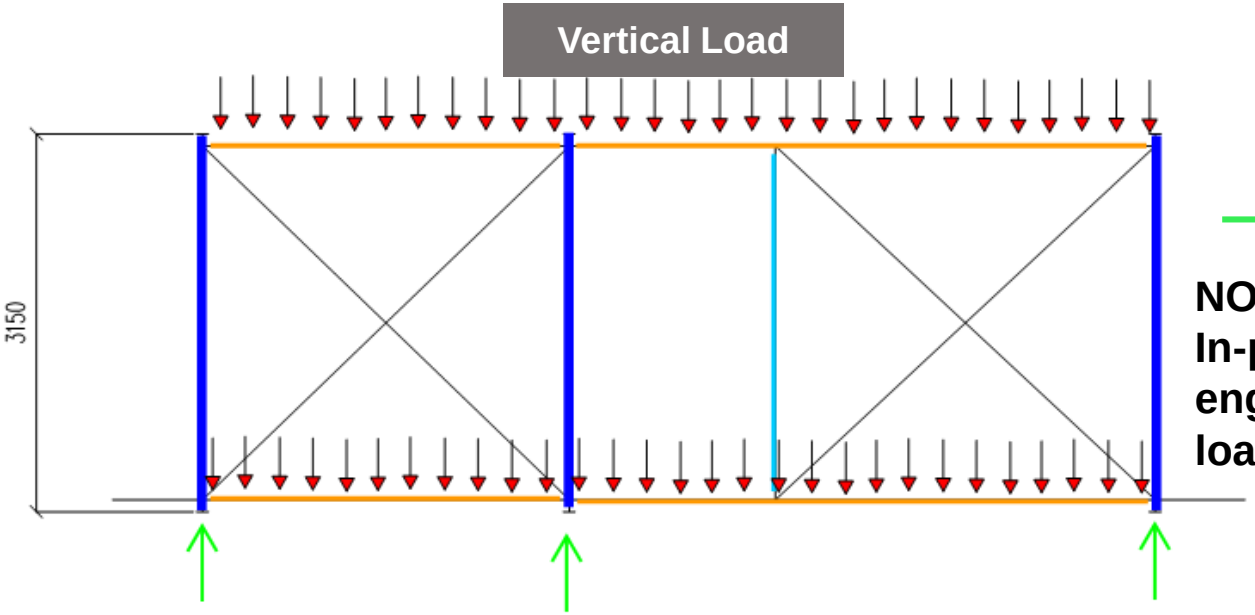
3. Module Fabrication and Construction Management

3.1 Typical PPVC Module



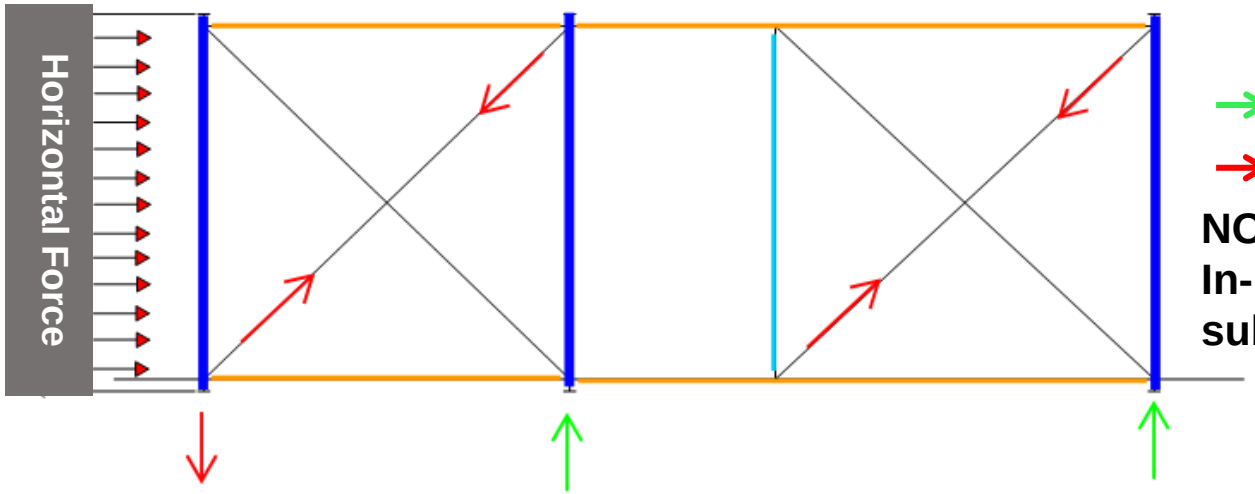


3.2 Load Transfer Path



→ Denotes: Compression

NOTE:
In-plane bracings are NOT engaged in resisting vertical loads



→ Denotes: Compression

→ Denotes: Tension

NOTE:
In-plane bracings are ONLY subjected to tension.

3.3 Scope of Works for PPVC

- Delivery logistics needs to be studied from overseas factory to local holding yard to site

Scope of Work at Oversea Factory

- Steel Structural Frame and Chassis
- Fin and Ledge Structure(Ship separately)
- Fire Rate Wall, Floor and Ceiling Board
- Internal Tiling Works
- Windows Frame and Glazing
- Façade
- Painting base and 1st Coat
- M&E Opening And Penetration

Scope of Work at Local Holding Yard

- Fins and Ledge
- Façade at Fin Area
- M&E Services and Fitting within Rooms
- Box-Up and Curtain Pelmet
- Cloths Drying Rack
- Fire Damper

Scope of Work at Site

- Waterproofed Sealant between modules
- Fire Rated Board and Façade between Modules
- Façade Along Linkway
- M&E Services Along Corridor
- Waterproofing and Tiling Along corridor and Linkway
- Final Panting
- Door Panel, FCU and Loose Furniture

3.4 PPVC Module Production and Installation

Scope of Work at Oversea Factory

- Steel Structural Frame and Chassis
- Fin and Ledge Structure (Ship separately)
- Fire Rate Wall, Floor and Ceiling Board
- Internal Tiling Works
- Windows Frame and Glazing
- Façade
- Painting base and 1st Coat
- M&E Opening And Penetration

Materiel Cutting

Materiel Assembly

Frame Fabrication

Frame Assembly

Welding

Trail Fitting

QC Inspection

Rock Wool and Fire Board Installation

Skim Putty

Façade and Window Installation

Tiling

Painting

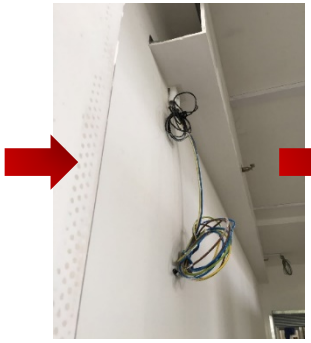
Scope of Work at Local Fitting Yard

- Fins and Ledge
- Façade at Fin Area
- M&E Services and Fitting within Rooms
- Box-Up and Curtain Pelmet
- Cloths Drying Rack
- Fire Damper

Electrical Work at Recess, Supporting Plate and Sealing Up

Weep Hole @ Toilet Recess and Electrical Final Fixing

M&E Interfacing Works

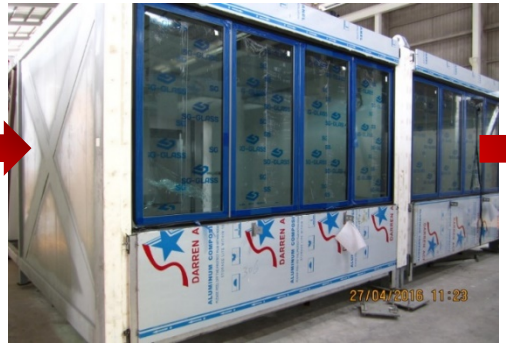


Installation of Box Up

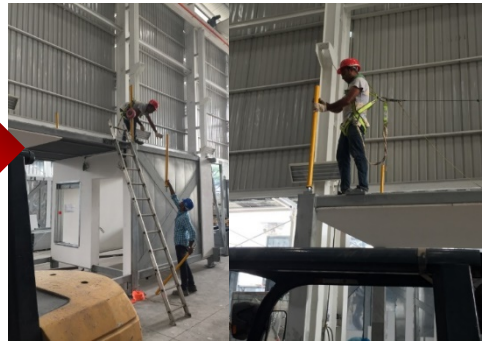
Pelmet and Fire Damper

Installation of Steel Frame for Fin and Ledge

MPI Testing @ Welding Joint



Installation Steel Frame and Façade



Safety Demo

Scope of Work at NTU Site

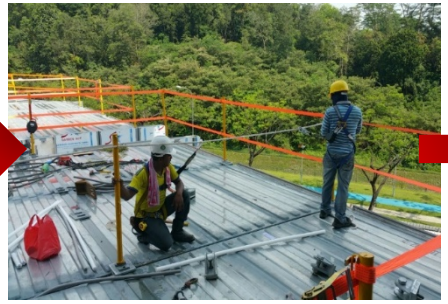
- Waterproofed Sealant between modules
- Fire Rated Board and Façade between Modules
- Façade Along Linkway
- M&E Services Along Corridor
- Waterproofing and Tiling Along corridor and Linkway
- Final Painting
- Door Panel, FCU and Loose Furniture

Setting up of final position of PPVC modules

1st PPVC module

Hoisting

Installation



Waterproofing Sealant at Roof of PPVC Modules

Installation of Link-way

Blocks

3.5 Construction Management

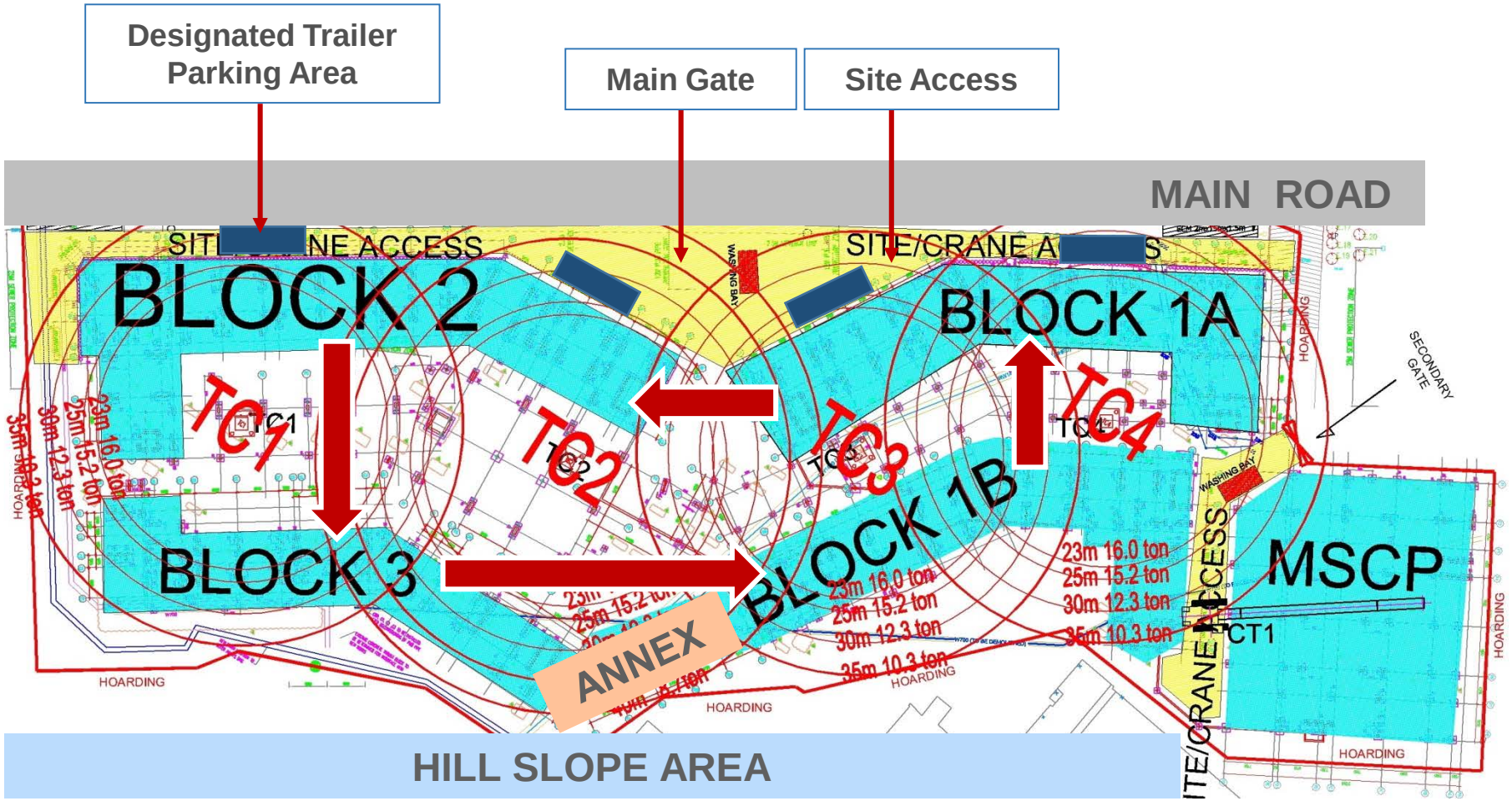
- **Construction schedule for NTU Crescent Hostel**

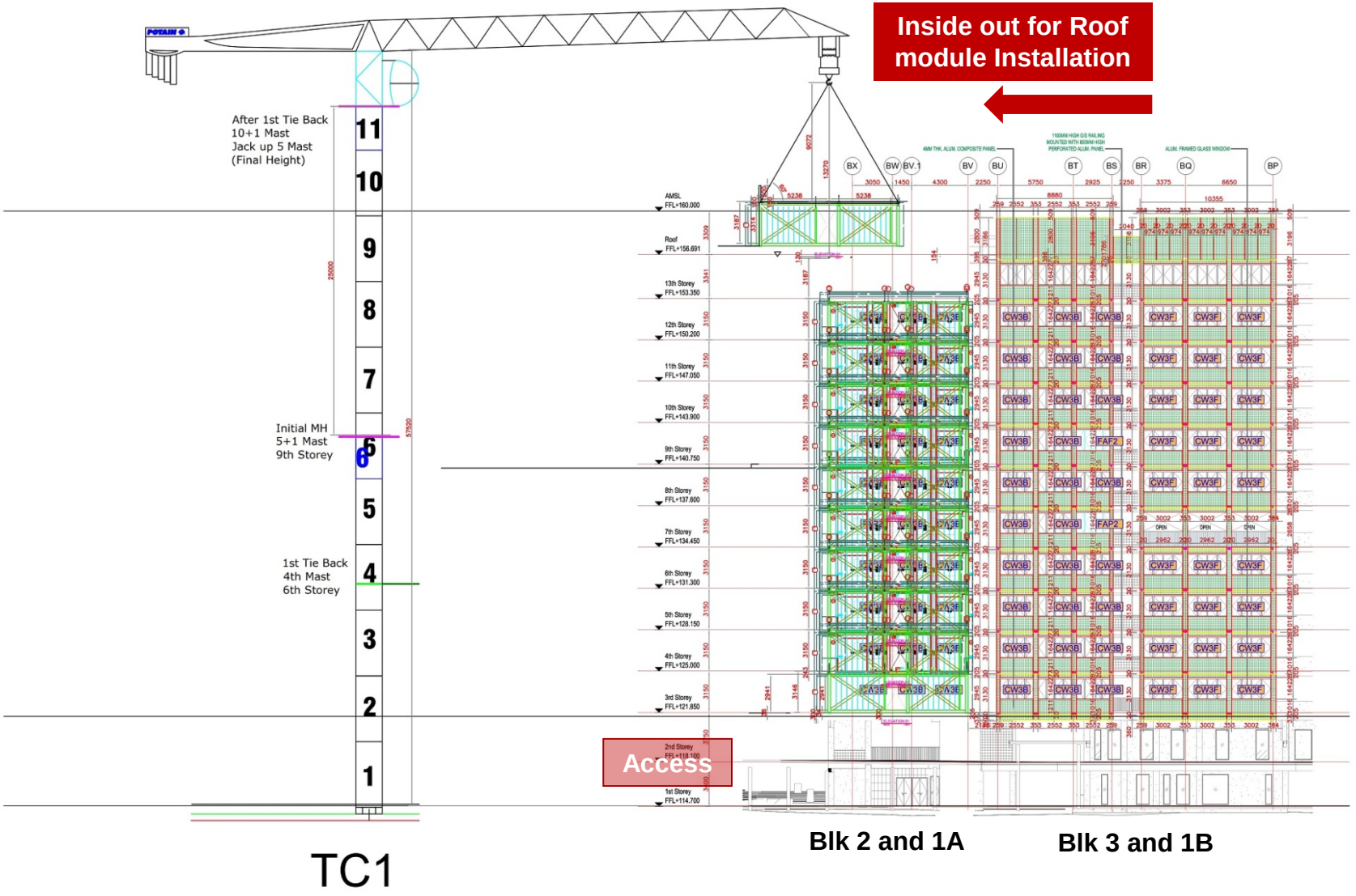
SANTARLI-ZHENG KENG JV

PROPOSED NTU STUDENT HOSTEL DEVELOPMENT AT NANYANG CRESCENT - PROGRAMME SUMMARY REV 0

Month	Jun-15 1	Jul-15 2	Aug-15 3	Sep-15 4	Oct-15 5	Nov-15 6	##### 7	Jan-16 8	Feb-16 9	Mar-16 10	Apr-16 11	May-16 12	Jun-16 13	Jul-16 14	Aug-16 15	Sep-16 16	Oct-16 17	Nov-16 18	Dec-16 19	Jan-17 20	Feb-17 21	Mar-17 22	Apr-17 23	May-17 24	Jun-17 25	Jul-17 26	Aug-17 27
PPVC Structural Design, AC And BCA Submission	3.75 mths -submitted on 21/9/15																										
BCA Approval for PPVC Structural Design				1 mth -Approved on 23/10/15																							
Transfer Slab Design, AC And BCA Submission				1.5 Months-Submitted on 9/10/15																							
BCA Approval For 3rd Sty Transfer Slab					1.25 Months -Approved on 16/11/15																						
PPVC Architectural Design And URA WP Submission	3.75 Months-submitted on 22/9/15																										
BCA/URA/FSSD Clearance For PPVC				1.25 Months-Approved on 29/10/15																							
Preliminaries And Site Setting Out	1 mth																										
MSCP Pilecap + Structural Works			6 mths																								
MSCP Site Architectural and M&E													15 mths														
Pilecap Construction for Main Building		2 mths				0.7 mth for 2nd sty pilecap																					
Blk 1A 1st - 3rd Sty Structural Works+transfer slab				4.5 mths																							
Blk 2 1st - 3rd Sty Structural Works+transfer slab				4.5 mths																							
Blk 3 3rd - 6th Sty Structural Works+transfer slab				4.5 mths																							
Blk 1B 1st - 3rd Sty Structural Works+transfer slab					5 mth																						
Cast In Situ 4th Sty- Roof										7 mths																	
Offsite Mockup with final fit and furniture			3.5 Months																								
PPVC Coordination Drawing & Material Submission and Consultant Approval			3 mths																								
Procurement of PPVC Structural And Architectural Materials (China)					2.3 mths																						
Manufacturing of Steelwork Frame Work at China (3M Per Day)									9.5 mths - 3 Modules Perday																		
Fixing Fireboard and Architectural work at China (3M Per Day)									9.5 mths - 3 Modules Perday																		
Shipment from China to Singapore Fabrication Yard																											
Final fitting of M&E, Ledge, Railing, Door frame etc at Moderna Singapore Fabrication Yard (3M Per Day)										10 mths - 3 Modules Perday																	
Delivery And Launching Of Module At Site (3M Perday)										1st Launching 23/3/16				8.0 mths - 3 Modules Perday													
Roof Slab and Pararet Wall																		1.7 mths									
Roof Waterproofing																				3.5 Months							
On Site Architectural and M&E																											
External Wall and Facade																					4 Months						
3RD STY LIVING STREET (EXTERNAL AREA)																					5 Months						
External Services		2 Mths- Drain Below 1st Sty Slab														9 Months											
External Works		2 Mths- Drain Below 1st Sty Slab																8 Months									
Linkway and Canopy																					5 Months						
Landscaping																					5.25 Months						
T&C and RI clearance																							1 mth				
TOP & Handing Over																											

- **Facilities Layout for NTU Crescent Hostel**




Inside out for Roof module Installation
After 1st Tie Back
10+1 Mast
Jack up 5 Mast
(Final Height)
Initial MH
5+1 Mast
9th Storey
1st Tie Back
4th Mast
6th Storey
11
10
9
8
7
6
5
4
3
2
1
Access
TC1
Blk 2 and 1A
Blk 3 and 1B

- **Construction Site - Overall View**

4. Other Considerations

4.1 Transportation Plan

- Set up a comprehensive Transportation Plan to analyze and mitigate issues brought about during deliveries. This is avoid potential damage to the module in long distance travel.
- The Transportation Plan shall comply with LTA's traffic regulatory requirements.
- Just-In-Time (JIT) delivery concept shall be studied with the transportation issues in order to ensure the followings:

i. The right time of delivery
ii. Manage site storage
iii. Optimize crane usage
iv. Minimize the hoist and handling of PPVC

4.2 Packaging, Protection and Labelling

- **Packaging**

The finished PPVC modules shall be controlled and inspected to ensure conformance with the specified and/or contracted requirements.

- **Protection**

The finished PPVC modules shall be provided to the extent necessary to prevent potential damage, deformation or deterioration of the installed finishing components and/or to the structure while in transit or during unloading at project site.

Corrosion Protection

Requirement:

All structural members are hot-dipped galvanized and comply with the requirements of ASTM A123/A123M. The average thickness of coating for all specimens tested shall conform to the requirement of the following table:

Minimum Average Coating Thickness Grade (Units: um)

Material Category	All Specimens Tested Steel Thickness Range (Measured), in. (mm)				
	<1/16 (<1.6)	1/16 to <1/8 (1.6 to <3.2)	1/8 to 3/16 (3.2 to 4.8)	>3/16 to <1/4 (>4.8 to <6.4)	≥1/4 (≥6.4)
Structural Shapes and Plate	45	65	75	85	100
Strip and Bar	45	65	75	85	100
Pipe and Tubing	45	45	75	75	75
Wire	35	50	60	65	80

- **Labelling**

The finished PPVC modules shall have the manufacturer's label and installed for identification.

4.3 Type of Hoisting Machinery

Characteristic of Crane	Tower crane	Mobile crane	Crawler crane
Crane Capacity	50 tons	700 tons	500 tons
Lifting Capacity	25 tons – 40 tons	25 tons – 40 tons	25 tons – 40 tons
Height of Equipment	120m	40m	80m
Radius of Work	40m	40m	40m

4.4 Steel PPVC Quality Checks

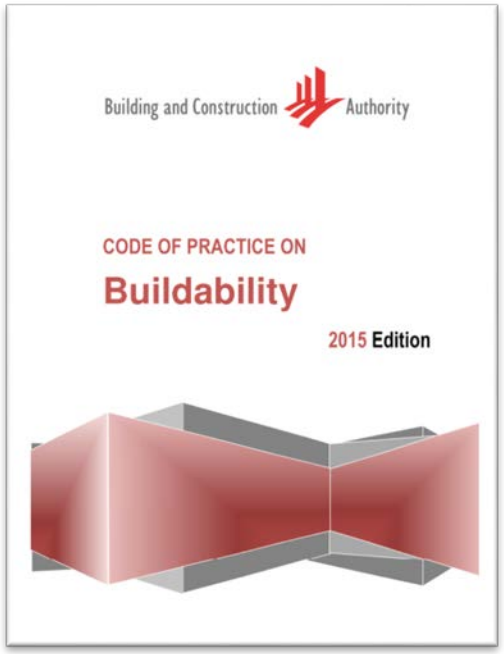
Structural Works	MEP Works	Architectural Works
1. Level and alignment 2. Verticality 3. Bulging 4. Position of continuity 5. Location of cast in items 6. Twisting of modules 7. Fire and corrosion protection 8. Structural opening position and dimension 9. MEP opening	1. Water tightness test 2. Pressure test 3. Cable continuity test 4. Earthing megger test 5. Electrical phase check 6. Shaft leakage inspection	1. Vertical and horizontal alignments 2. Levelling 3. Lightweight panel installation and QC check 4. Waterproofing application and QC check 5. Water ponding test 6. Tiling installation and QC check 7. Pull-out test 8. Spray test 9. Skim coating application and QC check 10. Floor finishes QC check 11. Kitchen and sanitary ware installation and QC check 12. Door and window installation and inspection 13. Railing installation and inspection 14. Painting application and inspection

5. Summary of Regulations

5.1 Statutory Requirements for PPVC

Min. Requirements & Acceptance Framework for PPVC under COP 2015

- Minimum usage of PPVC – **65%** of total super structural floor area or residential component.
- Minimum level of finishing & fittings to be completed off-site.
- Water Tightness & prevention of corrosion for steel.



Elements	Minimum level of completion off-site
Floor finished	80%
Wall finished	100%
Painting	100% base coat, only final coat is allowed on-site
Windows frames and glazing	100%
Doors	100%, only door leaves allowed for on-site installation
Wardrobes	100%, only doors allowed for on-site installation
Cabinets	100%, only doors allowed for on-site installation
MEP including water and sanitary pipes, electrical conduits and ducting	100%, only equipment to allowed for on-site installation
Electrical sockets and light switches	100%, only light fitting allowed for on-site installation

5.2 List of Regulations

S/N	Agency	Regulation
1	**Building construction Authority (BCA)**	Code of Practice on Buildability 2017
		CP82, BCA's Good Industry Practice Guide
		Technical Requirement for Storey Shelters 2015
		Technical Requirements for Household Shelters 2012
2	**Land Transport Authority (LTA)**	Rule 99 of Road Traffic Rules (OVM)
		Rule 2010 Promulgated under the Road Traffic Act (OVM)
3	**Singapore Civil Defence Force (SCDF)**	Fire Safety Act and Regulation "Code of Practice for Fire Safety Precaution in Buildings"
		Fire Safety Requirements for the use of Plastic in Building Construction, SCDF's circular dated 1 Oct 2014.
		Permitting Service within Fire -Rated Dry Construction in Buildings, SCDF's circular dated 13 Nov 2014.
4	**National Environment Agency (NEA)**	Code of Practice on Environmental Health, Singapore Standard SS593, COP on Pollution Control, Code of Practice on Sewerage and Sanitary Works, Environmental Protection and Management Act, and their Regulations, including the Environmental Protection and Management (Control of Noise at Construction Site) Regulation

S/N	Agency	Regulation
5	**Public Utilities Board (PUB)**	Singapore Standard CP 48: Code of Practice for Water Services
		1. Sewerage and Drainage Act 2. Sewerage and Drainage (Sanitary Works) Regulations 3. Code of Practice on Sewerage and Sanitary Works 4. Code of Practice on Surface Water Drainage 5. Public Utilities (Water Supply) Regulations
		BS EN 1253 -1, in event, if client preference for shallow floor trap (SFT) all relevant test shall comply with BS EN 1253 -1 as follows: 1. Anti- Blockage Test 2. Water Tightness Test 3. Flow Rate Test 4. Resistance to water seal to pressure 5. Odour Tightness Test 6. Depth of water seal 7. Access for Cleaning 8. Side Inlet
6	**Ministry of Manpower (MOM)**	Workplace Safety and Health Act 2014
		WSH (Exemption) Order 2011
		Workplace Safety and Health (Design for Safety) Regulation 2015

5.3 Building Innovation Panel (BIP) and PPVC Manufacture Accreditation Scheme (MAS)

- PPVC suppliers are require to obtain In Principle Acceptance (IPA) from the Building Innovation Panel (BIP).
- The acceptance framework consists of two parts (1) Evaluation of the PPVC system by the BIP (2) Meeting the PPVC Manufacturer Accreditation Scheme (MAS) requirements.

PPVC Accreditation Programme Jointly Developed by

Building and Construction Authority

SINGAPORE CONCRETE INSTITUTE

SINGAPORE STRUCTURAL STEEL SOCIETY

5.4 Singapore Standards, Cods of Practice and Good Industry Practice Guidebooks (References)

- CP 5: 1998 Code of Practice for Electrical Installations
- Code of Practice on Sewerage and Sanitary Works
- CP 48: 2005 Code of Practice for Water Services
- CP96: 2002 (2011) Code of Practice for Curtain Walls
- Code of Practice on Buildability 2017
- SS 608: 2015 Code of Practice for Gas Installation
- SS 555: 2010 Protection Against Lightning
- SS 553: 2009 Code of Practice for Air-conditioning and Mechanical Ventilation in Buildings
- SS 554: 2009 Code of Practice for Indoor Air Quality for Air-conditioned Buildings
- SS 212: 2007 Specification for Aluminium Alloy Windows
- SS 381: 1996 (2007) Materials and Performance Tests for Aluminium Curtain Walls
- EN1253-1 (shallow floor trap)
- In-built Bathrooms Performance Requirements
- Good Industry Practices Guide Book: Ceramic Tiling
- Good Industry Practices Guide Book: Marble and Granite Finishes
- Good Industry Practices Guide Book: Waterproofing for Internal Wet Areas
- Good Industry Practices Guide Book: Painting
- Good Industry Practices Guide Book: Timber Flooring
- Good Industry Practices Guide Book: Waterproofing for External Wall
- Good Industry Practices Guide Book: Aluminium Window
- Good Industry Practices Guide Book: Timber Doors
- Good Industry Practices Guide Book: Wardrobes and Kitchen Cabinets
- Good Industry Practices Guide Book: Precast Concrete Elements
- Good Industry Practices Guide Book: Drywall Internal Partition
- Good Industry Practices Guide Book: Design and Materials Selection (Vol 1)
- Good Industry Practices Guide Book: Design and Materials Selection (Vol 2)
- Design for Maintainability Checklist by BCA

Concluding Remarks - Challenges

- Timeline for PPVC design and authorities submission
- Structural analysis and design of critical connections
- Size and weight of the PPVC module v.s. crane capacity and transportation
- Scope of works at overseas factory, local fitting-out yard and project site
- Supervision at overseas factory and local fitting yard