CONTENTS

1. INTRODUCTION TO PPVC

2. PPVC CONSIDERATIONS AND KEY FACTORS
   2.1 TYPES OF PPVC MODULES
   2.2 TRANSPORTATION
   2.3 CONFIGURATION OF PPVC MODULES
   2.4 TYPE OF HOISTING MACHINERY
   2.5 COMPARISON OF RC AND STEEL MODULE

3. DESIGN CONSIDERATIONS
   3.1 ARCHITECTURAL DESIGN CONSIDERATIONS
      3.1.1 MODULARIZATION
      3.1.2 EARLY COORDINATION
      3.1.3 DIMENSION ON PLAN
      3.1.4 DIMENSION ON SECTION
      3.1.5 ALIGNMENT OF VERTICALLY AND HORIZONTALLY
      3.1.6 WATER-TIGHTNESS BETWEEN MODULES
      3.1.7 CONSIDERATION OF CONSTRUCTION TOLERANCE
   3.2 STRUCTURAL DESIGN CONSIDERATIONS
      3.2.1 MODULARIZATION
      3.2.2 STRUCTURAL MODELLING
      3.2.3 VERTICAL MODULES CONNECTION
      3.2.4 HORIZONTAL MODULES CONNECTION
      3.2.5 STRUCTURAL ROBUSTNESS
      3.2.6 MODULES CONNECTION TO CIVIL DEFENSE SHELTER WALL
      3.2.7 STRUCTURAL DESIGN OF MODULES
      3.2.8 PERIODIC STRUCTURAL INSPECTION (PSI)
CONTENTS

3. DESIGN CONSIDERATIONS (CON’T)
   3.3 MEP DESIGN CONSIDERATIONS
      3.3.1 ELECTRICAL SERVICES
      3.3.2 LIGHTNING PROTECTION
      3.3.3 WATER SUPPLY
      3.3.4 SANITARY DISCHARGE
      3.3.5 AIR-CONDITIONING AND MECHANICAL VENTILATION
      3.3.6 TOWN GAS
   3.4 FIRE SAFETY
      3.4.1 COMPLIANCE OF FIRE COMPARTMENTATION
      3.4.2 MATERIAL USAGE AFFECTING INTEGRITY OF MODULES

4. PPVC PRODUCTION
   4.1 MOULD PRODUCTION FOR REINFORCED CONCRETE MODULE
      4.1.1 CASTING TOLERANCES FOR THE MOULDS
      4.1.2 FABRICATION SCHEDULE
   4.2 STRUCTURE FOR REINFORCED CONCRETE MODULE
      4.2.1 REINFORCEMENT CAGE FABRICATION
      4.2.2 INSTALLATION OF CAST IN ITEMS
      4.2.3 SETTING AND INSTALLATION OF MOULD
      4.2.4 CONCRETE BATCHING AND PLACING OF CONCRETE
      4.2.5 DEMOULDING OF PPVC MODULES
      4.2.6 LIFTING AND STORING
   4.3 MEP WORKS
      4.3.1 MEP CONCEALED WORKS
      4.3.2 MEP FIRST FIX
      4.3.3 MEP FINAL FIT OUT
CONTENTS

4. PPVC PRODUCTION (CON’T)
   4.4 ARCHITECTURAL WORKS FOR REINFORCED CONCRETE MODULE
      4.4.1 ARCHITECTURAL WORKS (FINISHING LINE)
   4.5 STEEL PPVC PRODUCTION
      4.5.1 2D AND 3D JIG
      4.5.2 FABRICATION PROCESS

5. PROTECTION, TRANSPORTATION AND LIFTING
   5.1 TRANSPORTATION PLAN
   5.2 PACKAGING, PROTECTION AND LABELLING
   5.3 MODULE ROOF (TEMPORARY OR PERMANENT)

6. CONSTRUCTION AND PROJECT MANAGEMENT
   6.1 LOCATION OF THE PROJECT AND SURROUNDING
   6.2 ACCESS AND TRAFFIC MANAGEMENT FOR TRAILERS WITH HEAVY CARGO
   6.3 CONSIDERATION OF JUST IN TIME (JIT) OPERATION
   6.4 TYPES OF CRANE
   6.5 SAFETY
CONTENTS

7. REGULATIONS
   7.1 LIST OF REGULATIONS
   7.2 MINIMUM LEVEL OF OFF-SITE WORK FOR PPVC
   7.3 BUILDING INNOVATION PANEL (BIP) AND
       PPVC MANUFACTURER ACCREDITATION SCHEME (MAS)
   7.4 CODE OF PRACTICE AND GOOD INDUSTRY PRACTICE GUIDEBOOK

8. INSTALLATION
   8.1 ACCESS AND EGRESS
   8.2 VERTICAL AND HORIZONTAL ALIGNMENTS
   8.3 SEQUENCING OF THE MODULES
   8.4 SAFETY

9. MAINTENANCE, REPLACEMENT AND RENOVATION
   9.1 RENOVATION
      9.1.1 HOMEOWNER USER MANUAL

10. CRITICAL INSPECTIONS AND QUALITY CHECKS
    10.1 STRUCTURAL WORKS
    10.2 MEP WORKS
    10.3 ARCHITECTURAL WORKS
    10.4 QUALITY CHECKS
1. INTRODUCTION

To raise construction productivity and fundamentally change the design and construction processes, the industry is encouraged to embrace the concept of Design for Manufacturing and Assembly (DfMA), where construction is designed such that as much work may be done off-site in a controlled manufacturing environment as possible.

DfMA is a new approach in the construction industry. By bringing more work offsite, manpower and time needed to construct buildings are reduced, while ensuring work sites are safe, conducive and have minimal impact on the surrounding living environment. The use of prefabrication methods in construction has been promoted as a way to improve productivity in a traditionally manpower intensive industry.

Prefabricated Prefinished Volumetric Construction (PPVC) is one of the game changing technologies that support the DfMA concept to significantly speed up construction. Modular is a general construction term to describe the use of technology that facilitates off-site manufacturing. Complete modules made of multiple units complete with internal finishes, fixtures and fittings are manufactured in factories, and are then transported to site for installation in a Lego-like manner. In the hierarchy of DfMA methodologies, PPVC is one of the most efficient and complete principle in improving productivity.

In this book, the DfMA methodology on PPVC and the benefits reaped will be discussed so that there is better appreciation and confidence in the adoption and implementation of PPVC.
1. INTRODUCTION – COMPARISON

CONVENTIONAL CONSTRUCTION

In a traditionally manpower-intensive industry, most of the trade works involving structural, architectural, MEP and interior finishing works are constructed and installed on site.

PREFabricated pre-FINISHED VOLUMETRIC CONSTRUCTION (PPVC)

"Prefabricated Prefinished Volumetric Construction (PPVC)" means a construction method whereby free-standing volumetric modules (complete with finishes for walls, floors and ceilings) are:

a. constructed and assembled; or
b. manufactured and assembled, in an accredited fabrication facility, in accordance with any accredited fabrication method, and then installed in a building under building works.
1. INTRODUCTION

WHY PPVC? BENEFITS OF PPVC

PRODUCTIVITY IMPROVEMENT

- Fabrication of PPVC can proceed in parallel in the factory while other worksite activities are ongoing to streamline the construction process.
- The on-site construction can be significantly reduced through the use of PPVC.
- It can potentially achieve a productivity improvement of more than 40% in terms of manpower on site and time savings, depending on the complexity of the projects.

REDUCTION OF ON-SITE MANPOWER

- This will enhance worksite safety, as well as directing the manpower to better working conditions. More construction off-site leads to less time on-site and less individual man-hours working at height.
- By reducing construction and installation activities and manpower from the site and placing them off-site in a controlled factory environment, fewer workers will be on-site which in turn leads to fewer accidents and less down time.

BETTER CONSTRUCTION ENVIRONMENT

- As more activities are done off-site, a reduction of environment pollution can be ensured as dust and noise pollution can be minimised.
- Disamenities to the surrounding neighbourhoods during construction can be diminished.
- Prefabrication of the building modules also leads to cleaner worksites by generating less construction waste overall on-site.

BETTER QUALITY CONTROL

- PPVC delivers the majority of the final product from the controlled factory environment leading to increased reliability and yields higher quality finishing.
- Sequence of work can be planned more efficiently with better logistics coordination.

PPVC can be considered for multi-room accommodation such as:

- Residential
- Institutional
- Hotels/ hostels
- Nursing homes
- Dormitories
2. PPVC CONSIDERATIONS AND KEY FACTORS

2.1 TYPES OF PPVC MODULES:

The choice of material of the moulds will dictate the size and number of modules in the design as weight is a major consideration for the hoisting of the modules.

Other major factors will involve logistics of transportation, site layout and holding area, crane/hoisting location.

<table>
<thead>
<tr>
<th>Characteristic of module</th>
<th>CONCRETE</th>
<th>STEEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>Heavy</td>
<td>Light</td>
</tr>
<tr>
<td>Size</td>
<td>Relatively Smaller</td>
<td>Relatively Larger</td>
</tr>
<tr>
<td>No. modules</td>
<td>More modules required</td>
<td>Lesser modules required</td>
</tr>
</tbody>
</table>
2. PPVC CONSIDERATIONS AND KEY FACTORS

2.1 TYPES OF PPVC MODULES:

1. REINFORCED CONCRETE MODULE
   Wall: Concrete
   Floor: Concrete

2. STEEL MODULE
   Wall: Steel frame with lightweight walls
   Floor: Concrete or Lightweight Flooring
2. PPVC CONSIDERATIONS AND KEY FACTORS

2.2 TRANSPORTATION

Logistics for modules transportation from factory to site will determine the maximum size and volume of each module design, which in turn affects the number of modules to complete the layout.

The size of a single module should be limited to the dimensions allowed without requiring special measures such as police escort. Height consideration has to be factored in if the route involves passing through overhead bridges.

In compliance to LTA’s traffic regulatory requirements, Police Escort will not be required, when the parameters are controlled as indicated below:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>• Height</strong></td>
<td>&lt; 4.5 metre</td>
</tr>
<tr>
<td><strong>• Laden Weight</strong></td>
<td>&lt; 80 ton</td>
</tr>
<tr>
<td><strong>• Width</strong></td>
<td>&lt; 3.4 metre</td>
</tr>
</tbody>
</table>

Existing road configuration around the site has to be analyzed for the maneuvering and holding of the transportation. The deliveries have to be planned and coordinated to avoid congestion outside the site as especially for urban built-up areas.

Figure : transportation truck. *(Note : Dimension are for reference only.)*
2. PPVC CONSIDERATIONS AND KEY FACTORS

2.3 CONFIGURATION OF PPVC MODULES

The modules are arranged accordingly to the design layout. The geometry of the parts can be simplified to design for ease of production.

The number of modules varies based on the unit typology (Studio, 1 to 5 rooms). Total number of modules can typically range from 1 to 8 numbers per unit.

Demarcation of a typical unit module with reference to plan below is as follows:

- **MODULE A**: LRDIN (Living and Dining Room)
- **MODULE B**: B2-PBU (Bedroom 2 with In-built Bathroom)
- **MODULE C**: MB-PBU (Master Bedroom with In-built Bathroom)
- **MODULE D**: KIT (Kitchen)

*Figure: Typical 2-Bedroom Unit Modules.*
2. PPVC CONSIDERATIONS AND KEY FACTORS

2.3 CONFIGURATION OF PPVC MODULES

Figure: Typical 2-Bedroom Unit Modules.

Module A: LRDIN
Living and Dining Room

Module B: B2-PBU
Bedroom 2 with PBU

Module C: MB-PBU
Master Bedroom with PBU

Module D: KIT
Kitchen

Note: For reference only.
2. PPVC CONSIDERATIONS AND KEY FACTORS

2.4 TYPE OF HOISTING MACHINERY

Sizing and arrangement of cranes on a site will be dictated by the total lift weight of the module and the reach of the crane.

Below are some generic information on the type of cranes available.

<table>
<thead>
<tr>
<th>Characteristic of crane</th>
<th>( A ) Tower crane</th>
<th>( B ) Mobile crane</th>
<th>( C ) Crawler crane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crane Capacity</td>
<td>40 tons</td>
<td>700 tons</td>
<td>500 tons</td>
</tr>
<tr>
<td>Lifting Capacity</td>
<td>28tons/40m radius and 40tons/28m radius</td>
<td>25 tons</td>
<td>25 tons</td>
</tr>
<tr>
<td>Height of Equipment</td>
<td>120m</td>
<td>40m</td>
<td>80m</td>
</tr>
<tr>
<td>Radius of work</td>
<td>40m</td>
<td>40m</td>
<td>40m</td>
</tr>
<tr>
<td>Hoisting Speed</td>
<td>12-24m/min</td>
<td>12-24m/min</td>
<td>12-24m/min</td>
</tr>
<tr>
<td>Slewling Speed</td>
<td>180⁰/m</td>
<td>180⁰/m</td>
<td>180⁰/m</td>
</tr>
<tr>
<td>Slewling Angle</td>
<td>360⁰</td>
<td>360⁰</td>
<td>360⁰</td>
</tr>
</tbody>
</table>

Note: Actual crane requirement and capacity shall vary according to the site condition and to be obtained from the crane specialist accordingly.
2. PPVC CONSIDERATIONS AND KEY FACTORS

2.5 COMPARISON OF RC AND STEEL MODULE

<table>
<thead>
<tr>
<th></th>
<th>Reinforced Concrete Module (Monolithic)</th>
<th>Steel Module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>20 to 35 tons</td>
<td>15 to 20 tons</td>
</tr>
<tr>
<td>Handling and transportation</td>
<td>Protection to completed modules</td>
<td>Protection to completed modules</td>
</tr>
<tr>
<td></td>
<td>Permanent / temporary roof decking</td>
<td>Permanent / temporary roof decking</td>
</tr>
<tr>
<td></td>
<td>May require temporary stiffening</td>
<td>May require temporary stiffening</td>
</tr>
<tr>
<td>Installation method</td>
<td>Stacking method</td>
<td>Stacking method</td>
</tr>
<tr>
<td>Hoisting machinery</td>
<td>Hoisting by crane</td>
<td>Hoisting by crane</td>
</tr>
<tr>
<td>Familiarity to renovators in maintenance, replacement / renovation works.</td>
<td>Similar to conventional</td>
<td>To include info of supplier manual</td>
</tr>
<tr>
<td>Fire Compartmentation / rating</td>
<td>Similar to conventional construction</td>
<td>Material used and compartmentation shall comply with Code</td>
</tr>
<tr>
<td>Provision for Barrier-Free Accessibility Requirements</td>
<td>Similar to conventional construction</td>
<td>Similar to conventional construction</td>
</tr>
</tbody>
</table>

Note: For reference only.
3. DESIGN CONSIDERATIONS

3.1 ARCHITECTURAL DESIGN CONSIDERATIONS

3.1.1 MODULARIZATION

- Maximise repetition and standardisation in design, architectural features, structural components and MEP elements.

3.1.2 EARLY COORDINATION

- Early coordination among Architect, Structural Engineer and MEP Engineer, Builder, PPVC supplier and developer as this will dictate the layout, floor and ceiling height.
  - To consider the non-structural partition walls that can be removed in future.

3.1.3 DIMENSION ON PLAN

- To ensure the layout plan design comply to authority requirements.
- To ensure the size of modules allow transportation from factory to site.
- To consider the removable partition walls in design for future renovation.

Figure: Typical 2-Bedroom Unit Modules.
3. DESIGN CONSIDERATIONS

3.1 ARCHITECTURAL DESIGN CONSIDERATIONS

3.1.4 DIMENSION ON SECTION

- To ensure the floor to floor height comply to authorities requirements.
- To ensure the size of modules allow transportation from factory to site.
- To comply to authority requirement of ceiling height.
- To consider the single or double slabs situation.
- To maximise the useable room space.

![Typical Sectional Detail of Modules](image_url)

**FIGURE : TYPICAL SECTIONAL DETAIL OF MODULES**

Note: For reference only.
3. DESIGN CONSIDERATIONS

3.1 ARCHITECTURAL DESIGN CONSIDERATIONS

3.1.5 ALIGNMENT OF VERTICALITY AND HORIZONTALLY

- To consider the possible misalignment of floor, wall, ceiling at joints between modules.
- To consider the interfacing details between PPVC modules and in-situ part.

Possible vertical / horizontal misalignment of floor and wall finishes at joints between modules.

FIGURE : TYPICAL 2-BEDROOM UNIT PLAN

possible misalignment of ceiling finishes at joints between modules.

possible misalignment of floor and wall finishes at joints between modules.

FIGURE : TYPICAL SECTIONAL DETAIL OF MODULES
3. DESIGN CONSIDERATIONS

3.1 ARCHITECTURAL DESIGN CONSIDERATIONS

3.1.6 WATER-TIGHTNESS BETWEEN MODULES

- To consider the water-tightness details on vertical and horizontal joints of modules

FIGURE : TYPICAL 2-BEDROOM UNIT PLAN
3. DESIGN CONSIDERATIONS

3.1 ARCHITECTURAL DESIGN CONSIDERATIONS

3.1.7 CONSIDERATION OF CONSTRUCTION TOLERANCE

• To consider and allow construction tolerance on vertical and horizontal joints of modules and in-situ part.
3. DESIGN CONSIDERATIONS

3.2 STRUCTURAL DESIGN CONSIDERATIONS

3.2.1 MODULARIZATION

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. Early PPVC vendor’s involvement will be beneficial to the project. The modularization is largely affected by the sizes, dimensions, weights of PPVC modules and their transportability.

The weight of module in turn depends on the choice of PPVC material type, level of finishing, etc. The transportability of modules would be influenced by the planned delivery routes (i.e. from off-site prefabrication plants to the construction site) and types of trailer available in the industry.

Figure : Example of PPVC modularization during planning stage
3. DESIGN CONSIDERATIONS

3.2 STRUCTURAL DESIGN CONSIDERATIONS

3.2.2 STRUCTURAL MODELLING

3D modeling of building structures shall be carried out using suitable computer analysis software. In situations where module columns or walls are abutting each other, such twin column configuration should be considered in the 3D modeling.

In addition to the permanent design action conditions, extra modeling should be carried out to the PPVC modules with the designated number of lifting points included as temporary conditions (i.e. during hoisting operation).
3. DESIGN CONSIDERATIONS

3.2 STRUCTURAL DESIGN CONSIDERATIONS

3.2.3 VERTICAL MODULES CONNECTION

The vertical modules connection is crucial for the structural behaviour especially for the high rise buildings. It has direct effect to the building stiffness and its corresponding response under the wind, seismic (if applicable) and lateral design action conditions. Hence, the detailing of the PPVC vertical connection must satisfy the design intent.

3.2.4 HORIZONTAL MODULES CONNECTION

The horizontal modules connection forming the floor diaphragm, is equally important contributing to the overall building stiffness. In particular, the peripheral ties and internal ties shall be provided as per the Building Code requirement. The PPVC modules and layout shall be laterally connected and designed such that the horizontal forces (e.g. wind load) can be effectively transferred to the structure’s lateral load resisting system.

Due to the repetitions and as far as practicable, the horizontal joints should be designed in a manner that the implementation at site would be speedy and simple. A classic example for steel PPVC module joints is the bolting system whereas in concrete PPVC on-site grouting of joints is common.
3. DESIGN CONSIDERATIONS

3.2 STRUCTURAL DESIGN CONSIDERATIONS

3.2.5 STRUCTURAL ROBUSTNESS

The design of PPVC building shall give due consideration to the scenario of accidental One Column or Wall removal; The inter-connected volumetric system must be capable of redistributing the internal forces to the nearest load bearing elements such that progressive collapse is totally prevented.

Figure : Notional removal of PPVC wall panel

Figure : Cantilever Action of Modules due to PPVC removal
3. DESIGN CONSIDERATIONS

3.2 STRUCTURAL DESIGN CONSIDERATIONS

3.2.6 MODULES CONNECTION TO CIVIL DEFENCE SHELTER WALL

It is mandatory for residential building projects to incorporate either Household Shelters (HS), Storey Shelters (SS) or Staircase Storey Shelters (SSS) as Civil Defence (CD) Shelter. In situation when PPVC modules are abutting the CD shelter, effective connection between the abutting PPVC modules and CD shelter walls at each storey level is to be provided. The connection capacity shall be at lease equivalent to that of the connection using RC slab. The connection details should take into account of the construction sequence of shelter walls, launching of precast staircase flights (for SSS), casting of shelter floor slab and installation of abutting PPVC module(s), 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.

Figure : Modules connection to civil defense shelter.
3.2 STRUCTURAL DESIGN CONSIDERATIONS

3.2.7 STRUCTURAL DESIGN OF MODULES

In addition to the normal elemental design under the permanent design actions, it is necessary to carry out structural analysis of transient design situation (e.g. during handling in the precast plant) to the PPVC modules considering the designated lifting points during hoisting and erection. Serviceability limit checks should be strictly performed to prevent cracks to the concrete slab or walls during handling and transporting.

The lifting hooks and number of points must be strategically positioned such that sufficient bond anchorage can be developed to hoist the entire module safely and that the load distribution to all lifting points are reasonably uniform. It is a good practice to hoist PPVC module with the aid of steel collar frame so that the module would not be subject to inclined forces from the lifting wires.

Broadly there are two types of framing system for concrete PPVC modules, namely:

a) Beam-Column system, in which the beam profiles can be visible without false ceiling.

b) Slab-Shear wall system, in which no beam is required for the module framing

---

Figure: Modules with lifting hooks
3. DESIGN CONSIDERATIONS

3.2 STRUCTURAL DESIGN CONSIDERATIONS

3.2.8 PERIODIC STRUCTURAL INSPECTION (PSI)

For Steel PPVC projects, due considerations shall be given to Periodic Structural Inspection (PSI) during design and planning phase. Inspection access points are to be provided for the inspection of critical structures such as steel beams and column joints. Inspection locations and methodologies shall be identified at the onset and be included in the Coordinated plans. This would enable the Structural Inspector to conduct Periodic Structural Inspections in the future without causing major inconvenience to the building occupants.

![Access panels and Inspection point](image)

*Figure: Periodic Structural Inspection Point (PSI)*
3.3 MEP DESIGN CONSIDERATIONS

• **Typical MEP services**
  Electrical, lightning protection, water supply, sanitary, ACMV, gas, and any other system are part of PPVC.

• **AMEP Coordination**
  Early coordination of services will be advantageous. Constraints for installation and maintenance could be addressed early to avoid impact on pre-finished works in later stage. Upfront design coordination in conjunction with structural prefabrication component is important.

• **Impacts to Structure and Fire Safety**
  Necessary openings, recess and concealed components shall be included in consideration for structural strength, fire safety measures and other relevant design.

• **Integrity of MEP Services**
  Continuity and system integrity of all MEP services shall be taken care of. Due to the modularization nature of PPVC, connection of MEP system components between modules may be required. Connection methodology shall not compromise integrity and performance of the system.

• **Accessibility for Installation and Maintenance**
  Means of installation shall enable ease of maintenance or future replacement when necessary. Space for installation, maintenance and future replacement shall be allocated.

• **Design and Construction Errors**
  Tolerance of gradient of pipe-works connections shall be considered. Angle and leveling of fittings may be affected after the module is positioned in-place. Design and planning shall consider tolerance of these level differences.
3.3.1 Electrical Services

- Connection of components including conduit, cable trunking and tray, cable
- Joint of cable infrastructure between modules to ensure proper protection for cable.
- Joint of cable shall ensure complete continuity with acceptable connection methodology.
- Concealed cable infrastructure not to compromise fire safety.

Figure: Electrical Services
### 3.3.2 Lightning Protection

- Connection of lightning conductor.
- Connection joint shall ensure proper conductivity.
- If structure rebar and/or structural steel section is used as conductor, proper measures to be taken to prevent erosion of conductor.

![Lightning conductor connection between modules](image)

### 3.3.3 Water Supply

- Connection of components shall be able to withstand pressure required.
- Concealed components embedded in structural elements shall be taken into consideration for structural strength design.

![Water Supply routing and connection between modules](image)
3.3.4 Sanitary Discharge

- Concealed components embedded in structural elements shall be taken into consideration for structural strength design.
- To allow working space for pipe connection between modules.
- To consider potential slab thickening factor for use of shallow floor trap, including impact on weight, transportation and storage requirements.
- To consider for sufficient space and proper protection for pre-installed S-trap and P-trap.
- To consider mounting type of WC (floor-mounted or wall-mounted).
- Proper protection to all protruding and exposed pipeworks from mechanical damage during transportation, storage and shifting of modules.
- To protect pre-installed pipeworks from heat, ultra-violet radiation and other necessary factors.
- Method for future repairing works for clogging or leakage shall be taken into design consideration.

Conventional Floor Trap

Shallow Floor Trap
3.3.5 **Air-Conditioning and Mechanical Ventilation**

- Connection of air-conditioning components including refrigerant pipe, condensate drain pipe, respective insulation layer, and wiring.

- Joints of refrigerant pipe, if required, shall be able to withstand operating pressure and not to be eroded easily.

- Maintenance and repairing measures shall be taken into consideration.

- Connection of mechanical ventilation components including mechanical fan, air-duct and wiring.

- Inspection and replacement access for equipment such as mechanical fan shall be reserved.

*Figure: Air-Conditioning and MV routing.*

3.3.6 **Town Gas**

- Connection of town gas supply shall be able to withstand town gas supply pressure and free from leakage.

- Joints shall be treated necessarily to prevent corrosion.
3. DESIGN CONSIDERATIONS

3.4 FIRE SAFETY

The cellular nature of the PPVC modules means that fire safety has to be considered individually and as a whole building. Compartmentation is the main mode of fire protection to prevent fire spread.

3.4.1 Compliance of fire compartmentation

- Fire resistance rating required of the elements of structure of the building.
- Party wall and slabs segregating dwelling units.
- Compartment walls segregating the dwelling units and fire fighting lobby.

Figure : Example of tower block plan

Figure : Horizontal separation.
3. DESIGN CONSIDERATIONS

3.4 FIRE SAFETY

3.4.1 Compliance of Fire Compartmentation

Provision of documental proofs and detail drawings to illustrate compliance of fire code requirements of the proposed system in terms of compartmentation, material usage etc. A fire safety engineer could be engaged to conduct fire safety review of the system where relevant. Sectional plans shall show the fire protection details and elements.

3.4.2 Material Usage affecting integrity of modules

• Detail of the use of the plastic materials on floor, walls and ceilings, if any.
• Types and integrity of fire rated board system, if any.
• Fire test performance reports and related certification bodies accredited by Singapore accredited counsel for proposed system and fire safety products certificates

Figure : Concealed Services in the Ceiling Space
4. PPVC PRODUCTION

4.1 MOULD PRODUCTION FOR REINFORCED CONCRETE MODULE

Moulds are fabricated in steel with comprehensive design to withstand the handling and production process for the life time required in production. And these moulds are three dimensional and may be adjustable to cater for few combination of dimensions. The factors that influence the concept of mould design are as follows,
4. PPVC PRODUCTION

4.1 MOULD PRODUCTION FOR REINFORCED CONCRETE MODULE

4.1.1 Casting tolerances for the moulds

- casting tolerance of the modules are controlled from the acceptable tolerance of the modules produced from the moulds

- Verticality: +/-1 mm for m

- Squareness: 1mm for 300mm

- Concrete cover: +2mm

- Cross section dimensions: +/- 2mm

- Opening sizes for door and window: +5mm

4.1.2 Fabrication schedule:

Moulds are to be fabricated upon the approval of mould shop drawings, which should be based on the approved details and approved shop drawings. The schedule will define the equality of moulds with the factor of cost as the schedule is tight between the confirmation of drawings and production.

Quantity of the modules cast per mould

Mould Mechanism

Cycle Time and Production
4. PPVC PRODUCTION

4.2 STRUCTURE WORKS FOR REINFORCED CONCRETE MODULE

4.2. Structure works

Prefabricated Prefinished Volumetric Concrete (PPVC) can be produced by integrating structures like column, beam, wall and slab as a single module. The production process for the manufacture of Reinforced Concrete for Prefabricated Prefinished Volumetric Concrete Modules comprise of the following steps:

4.2.1. Reinforcement Cage Fabrication

The reinforcement cage is prepared using the rebar jig before shifting into volumetric moulds. Ribbed wire shall be tied onto the straight bar according to the specified spacing requirement in the shop drawing to prepare the cages. All steel reinforcement shall be placed and to be checked / inspected.

4.2.2 Installation of cast in items

All the cast in items shall be placed on location as per approved shop drawings to ensure all the installed cast in items shall comply with the relevant specification for the relevant discipline (Archi and MEP cast in items). All the cast in items shall be checked / inspected before closure of the moulds.
4. PPVC PRODUCTION

4.2 STRUCTURE WORKS FOR REINFORCED CONCRETE MODULE

4.2.3 Setting and Installation of Mould

The steel mould (inner and outer) shall be cleaned and mould oil shall be applied onto the surface of mould in accordance to amount recommended by manufacturer before placing of reinforcement. Cover blocks made from cement mortar or plastic spacer are allowed for ensuring that reinforcements are correctly positioned so that they will not overturn when concrete is placed and to provide the minimum cover as specified in the shop drawing.

The QP/RE/RTO shall inspect the assembled moulds according to the pre-pour checklist. After successful completion of inspection concrete order shall be placed.
4. PPVC PRODUCTION

4.2 STRUCTURE WORKS FOR REINFORCED CONCRETE MODULE

4.2.4 Concrete Batching and Placing of Concrete

Concrete shall be batch according to the approved concrete mix design provided by Ready Mixed Concrete (RMC) supplier and approved by Structural Engineer. Quality control of batch concrete shall follow quality procedures set out by the RMC.

Placing of Concrete

During the placing of layers, the internal poker vibrators shall be used. Thereafter, the external vibrators shall be engaged to ensure air is displaced from concrete to produce a dense homogenous mass.

After placing and compacting the last layer, the concrete shall be finished using a steel trowel to produce a smooth and level finish.
4. PPVC PRODUCTION

4.2 STRUCTURE WORKS FOR REINFORCED CONCRETE MODULE

4.2.5 Demoulding of PPVC modules

Prior to dismantling of outer and inner mould for the core, the concrete cubes shall be tested to ensure that the concrete has achieved a compressive strength of specified by QP.

The outer and inner mould for the core shall be released in order to lift the volumetric modules from it’s moulds. The moulds shall be released based on the supplier’s operation manual for all volumetric.

4.2.6 Lifting and Storing

• The volumetric modules shall be removed from the mould using appropriate lifting frames once the compressive strength of concrete has achieved the minimum required strength specified by QP.

• All modules/precast panels must hoist with the load vertically using the lifting frame.

• The volumetric modules shall be stored at designated storage location in order to carry out the touching up and finishing works.

• Timber wedges & sand bags shall be placed at the bottom of the volumetric modules so that, modules do not come in contact with the uneven grounds and damage the volumetric modules.

• The Engineer/RTO or his assignee shall inspect the concrete surfaces for any surface defects and shall be rectified according to the approved repair procedures.
4. PPVC PRODUCTION

4.3  MEP WORKS FOR REINFORCED CONCRETE MODULE

4.3.1  MEP Concealed works

MEP concealed component are installed in-conjunction with the structural prefabrication process (1). Installation of components shall not weaken structural element. The components shall be secured firmly to ensure the required positioning. (2) Joints openings shall be protected. Necessary recess or penetrations on structural elements shall be in-place (3).

4.3.2  MEP first fix

After structural concreting works, MEP components shall be connected prior to the Architectural finishing works (4). Testing on component installed prior to Architectural works is essential. Proper support shall be provided to minimize impact upon transportation (5). Tolerance should be provided for pipe-works requiring gradient.

4.3.3  MEP final fit-out

MEP final fittings including switches, socket outlet, water tap, mixer, basin, WC, flus valve etc. are to be installed before delivery to site. All fittings are to be protected. Protection methodology shall include consideration on impact from humidity, temperature, vibration due to transportation and other relevant factors. Essential to keep tolerance for final leveling.
4. PPVC PRODUCTION

4.4  ARCHITECTURAL WORKS FOR REINFORCED CONCRETE MODULE

4.4.1  Architectural Works (Finishing Line)
4. PPVC PRODUCTION

4.4 ARCHITECTURAL WORKS FOR REINFORCED CONCRETE MODULE

4.4.1 Architectural Works (Finishing Line)
4. PPVC PRODUCTION

4.5 STEEL PPVC PRODUCTION

In order to ensure the accuracy of the final product, special care must be given to each fabrication process, starting from design and fabrication of 2D and 3D jigs, procurement and preparation of structural steel member and the selection of the process, work sequence, method, machine and the consumable used in the welding work.

4.5.1 2D and 3D Jig

The jigs used in the fabrication work are designed and fabricated to withstand the additional force cause by heat transmitted between and within the steel section to ensure the accuracy of the 2D frame and 3D carcass remain unchanged during and after welding work.

Total number of jigs required for each project is determined by the design and type of modules, the fabrication schedule/rate and the flexibility of the jigs and is different from project to project.
4. PPVC PRODUCTION

4.5 STEEL PPVC PRODUCTION

4.5.2 Fabrication Process

- Validation of raw material against FPC and Mill Cert
- Preparation and cutting of material
- Engraving for ease of identification and validating of galvanized thickness
- Fitting and welding of steel members to 2D frame

next page
4. PPVC PRODUCTION

4.5 STEEL PPVC PRODUCTION

4.5.2 Fabrication Process

- Fitting and welding of 2D frame into 3D carcass
- QC check on welding quality
- Trial stack to ensure overall dimension and accuracy
- Installation of M&E piping/conduit

Next page
4. PPVC PRODUCTION

4.5 STEEL PPVC PRODUCTION

4.5.2 Fabrication Process

Installation of drywall - studs, insulation, fireboard and/or plaster board

QC check - on drywall quality

Waterproofing and water ponding test

Tiling work - for floor and wall

Next page
4. PPVC PRODUCTION

4.5 STEEL PPVC PRODUCTION

4.5.2 Fabrication Process

- QC check and tile protection
- Installation of window frame, glazing and water tightness test
- Installation of window grille and door frame
- Installation of external cladding and ledge

next page
4. PPVC PRODUCTION

4.5 STEEL PPVC PRODUCTION

4.5.2 Fabrication Process

- Painting - basecoat, 1st coat and 2nd coat
- Installation of wardrobe and fixing of plumbing/sanitary ware
- Protection of modules (from water ingress) before delivery
- Delivery and installation of PPVC modules
4. PPVC PRODUCTION

4.5 STEEL PPVC PRODUCTION

4.5.2 Fabrication Process

modules installed on site
5. PROTECTION, TRANSPORTATION AND LIFTING

5.1 TRANSPORTATION PLAN

To ensure the quality of product conformity are being delivered on site, the transportation plan is significant to mitigate the transportation issues associated with traffic condition at borders during peak hours considering the carcass to be cast overseas and delivered to finishing factory to carried out the balance finishing trades then transported to construction site for installation. The deliveries have to be planned and comply with LTA’s traffic regulatory requirements.

At the same time Just In Time delivery concept shall be studied with the transportation issues In order to ensure
1. The right time of delivery,
2. manage the site storage,
3. Optimize the crane usage,
4. Minimize the hoist and handling of PPVC
5. PROTECTION, TRANSPORTATION AND LIFTING

5.2 PACKAGING, PROTECTION AND LABELLING

1. Packaging of the finished product of PPVC shall be controlled and inspected to ensure conformance with the specified and/or contract requirement.

2. The protection to completed PPVC modules shall be provided to the extent necessary to prevent potential damage, deformation or deterioration on the installed finishing components and/or to the structure while on transit or during unloading on project site. This includes the provision of appropriate protection sheet to internal finishes and to external surface of structure.

3. All finished PPVC shall have the manufacturer’s label and installed for identification.

5.3 MODULE COVER (TEMPORARY OR PERMANENT)

- Roof shall be manufactured according to size and design requirement.
- Temporary or permanent roofing method, depends on the project specification and should sought approval prior to installation.
- Installation of roofing shall be inspected and approved prior to be subjected to any handling.
6. CONSTRUCTION AND PROJECT MANAGEMENT

6.1 LOCATION OF THE PROJECT AND SURROUNDING
   • The condition of the roads surrounding the project has to be able to accommodate to the weight and size of the PPVC modules delivery.

6.2 ACCESS AND TRAFFIC MANAGEMENT FOR TRAILERS WITH HEAVY CARGO
   • The access to and within the site must be able to accommodate trailers with heavy cargo. Slopes and undulating terrain might prove to be a challenge for heavy vehicle. The turning radius of the trailers have to be considered during the planning stage for the site as well to avoid choking of access for vehicle.
   • Trailers with heavy cargo pose potential hazards upon entering site and while navigating within the site. Traffic controller has to be employed for smooth traffic management within the site.

6.3 CONSIDERATION OF JUST IN TIME (JIT) OPERATION
   • Unlike conventional precast, PPVC modules could not be stack to be stored on site. Therefore, a Just in Time installation could prove to be efficient and productive. The rate of installation has to be determine for a smoother JIT operation.
   • In an event which JIT installation is not possible, e.g. Increment weather. It is advisable to have space for unloading and storage.
6. CONSTRUCTION AND PROJECT MANAGEMENT

6.4 TYPES OF CRANE

- The crane employed must be able to handle the weight of the PPVC modules but at the same time, be able to provide enough coverage for the intended block.

6.5 SAFETY

- Thorough Risk assessment has to be conducted to identify all potential hazards. Appropriate control measures must then be set up, communicated and implemented before the commencement of works.

- A comprehensive Fall Prevention Plan with Safe Work Procedure and appropriate control measures has to be established. Control measures such as safety barricade shall be provided for all open sides where a person may fall. Such barricade can only be removed during installation when the precast component is hoisted near to its designated position.
6. CONSTRUCTION AND PROJECT MANAGEMENT

6.5 SAFETY (Cont.)

• All workers who are carrying out work at height shall be provided with the appropriate Personal Protective Equipment such as personal fall arrest system. They shall be trained in the proper use of the system and ensure that the system is in place at all times.

• All lifting gears and equipment are to be in serviceable condition. Checks has to be conducted by Authorised Examiners periodically to ensure workers are working with safe and functional equipment.
# 7. REGULATIONS

## 7.1 LIST OF REGULATIONS

<table>
<thead>
<tr>
<th>S/N</th>
<th>AGENCY</th>
<th>REGULATION</th>
</tr>
</thead>
</table>
| 1   | Building Construction Authority (BCA) | COP on Buildability 2015  
CP82, BCA’S Good Industry Practice Guide  
Technical Requirements for Storey Shelters 2015  
Technical Requirements for Household Shelters 2012 |
| 2   | Land Transport Authority (LTA) | Rule 99 of Road Traffic Rules (OVM)  
Rules 2010 Promulgated under the Road Traffic Act (OVM) |
Fire Safety Requirements for the use of Plastic in Building Construction. FSR 2014 |
| 4   | National Environment Agency (NEA) | Code of Practice on Environmental Health, Singapore Standard SS593, COP on Pollution Control, COP on Sewerage and Sanitary Works, COP on Surface Water Drainage, Sewerage, and Drainage Act, Environmental Protection and Management Act, and their Regulations, including the Environmental Protection and Management (Control of Noise at Construction Site) Regulation. |
| 5   | Public Utilities Board (PUB) | Singapore Standard CP 48 : Code of Practice for Water Services  
BS EN 1253-1, in event, if client preferences for shallow floor trap (SFT) all relevant Test shall comply to 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 |
### 7.2 MINIMUM LEVEL OF OFF-SITE WORK FOR PPVC

<table>
<thead>
<tr>
<th>Elements</th>
<th>Minimum level of completion off-site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor finishes</td>
<td>80%</td>
</tr>
<tr>
<td>Wall finishes</td>
<td>100%</td>
</tr>
<tr>
<td>Painting</td>
<td>100% base coat, only final coat is allowed on-site</td>
</tr>
<tr>
<td>Windows frame and Glazing</td>
<td>100%</td>
</tr>
<tr>
<td>Door</td>
<td>100%, only door leaves allowed for on-site installation</td>
</tr>
<tr>
<td>Wardrobe</td>
<td>100%, only doors are allowed for on-site installation</td>
</tr>
<tr>
<td>Cabinets</td>
<td>100%, only doors are allowed for on-site installation</td>
</tr>
<tr>
<td>MEP including water and sanitary pipes, electrical conduits and ducting</td>
<td>100%, only equipment to allowed for on-site installation</td>
</tr>
<tr>
<td>Electrical sockets and light switches</td>
<td>100%, only light fittings allowed for on-site installation</td>
</tr>
</tbody>
</table>

*SOURCE: CODE OF PRACTICE ON BUILDABILITY, 2017 EDITION*
To ensure quality and address potential downstream issues for local projects:

- PPVC suppliers are required 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*

[Images of logos for BCA, Singapore Concrete Institute, and Singapore Structural Steel Society]
7. REGULATIONS

7.4 CODE OF PRACTICE AND GOOD INDUSTRY PRACTICE GUIDEBOOK

- 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
- 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
- EN1253-1 (shallow floor trap)
- Public Utilities (Water Supply) Regulations
- Sewerage and Drainage Ac
- COP on Buildability 2015
- In-built Bathrooms (PBU) 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: Aluminium Window
- Good Industry Practices Guide Book: Timber Doors
- 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)
8. INSTALLATION

8.1 ACCESS AND EGRESS

- An access has to be provided for workers to move in and out during an installation. Any open area will have to be covered with safety barricade to prevent any worker from falling from height. A clearly demarcated egress has to be provided as well to allow workers to exit the work area in case of emergency.

8.2 VERTICAL AND HORIZONTAL ALIGNMENTS

- Improper alignments both vertically and horizontally may cause multiple issues such as water stagnation as well as tiles misalignments. A proper Method of Statement is recommended to ensure workers are well informed in dealing with alignments during installations.

- MEP services including lightning protection system, sanitary and rain water discharge system etc. require proper vertical continuity connection. Installation of P-trap, S-trap if required, shall not impact on finishes done up in factory. If vertical concealed shaft is provided, space for installation works shall be allocated to facilitate vertical connection works.
8. INSTALLATION

8.2 VERTICAL AND HORIZONTAL ALIGNMENTS (cont’)

- For MEP services that require installation works horizontally crossing modules, including wiring, pressurized pipeworks, gradient pipeworks. Method of wiring connections, if required, shall not compromise level of continuity. All point of connections shall be properly secured by proper support. Method of connections shall not compromise gradient required for gradient-pipeworks. Proper protection to finishes if hot work is required for connections. Installation works shall be done via space allocated for installation works.

8.3 SEQUENCING OF THE MODULES

- It will be useful to work out the installation sequence of components to best maximise the productivity during installation. E.g. it might be easier to install modules facing the external and work towards the inner modules.

8.4 SAFETY

- Workers are prone to high risk activities such as Lifting Operation and Fall from Height. Proper safety instruments has to be provided to ensure the well-being of the workers are taken care of.

- Safety documents such as Risk Assessment and Safe Work Procedure has to be submitted and vetted thoroughly by the site safety officer. Safety Instrument has to be check regularly and daily Permit to work has to be submitted dutifully to ensure workers are working in a safe environment.
9. MAINTENANCE, REPLACEMENT AND RENOVATION

9.1 RENOVATION

It is essential to exercise care during renovation to prevent damage to the unit. A trained renovator should be engaged who should use appropriate tools and follow the instructions in the homeowner user manual.

- Renovator should be trained.
- It is important to use appropriate tools for renovation works.
- Exercise care when renovating, replacing tiles, etc. by referring to the homeowner user manual.
9. MAINTENANCE, REPLACEMENT AND RENOVATION

9.1.1 HOMEOWNER USER MANUAL

Besides engaging renovation contractors who are trained, homeowners should have a ready reference of the PPVC system used in the unit. It is good practice for developers/builders to provide a homeowner user manual of the PPVC upon completion of the project. The homeowner and subsequent buyers of the unit should obtain a copy of the homeowner user manual after taking over the unit and follow the recommendations on PPVC recommendations on PPVC renovation provided in the manual.

The information in the homeowner user manual could include (but not limited to) the following:

(a) General information on PPVC
   (i) Introduction to the PPVC installed
   (ii) Safety notices
   (iii) Instruction for use

(b) Structure of the PPVC
   (i) Floor
   (ii) Wall
   (iii) Ceiling
   (iv) Water piping
   (v) Sanitary discharge pipe/vertical soil stack
   (vi) Electrical conduits

(c) Layout of the PPVC
   (i) General layout
   (ii) Waterproofing layout
   (iii) Locations of concealed services
   (iv) Location of access panel
   (v) Location of the manufacturer’s label

(d) Cleaning and maintenance advice
   (i) Internal fittings, tiles and accessories
   (ii) Floor trap
   (iii) Ceiling access panels

(e) Alteration, repair and replacement works
   (i) Replacement of accessoriesinstallation of additional fittings
   (ii) Availability and supply of spare parts
   (iii) Instructions for drilling and fixing
   (iv) Instructions for tile replacement
   (v) Instructions for grab bars installation
10. CRITICAL INSPECTION AND QUALITY CHECK

10.1 STRUCTURAL WORKS

• Level and Alignment
  The level and alignment shall remain within the allowable tolerance to mitigate jog during installation.

• Verticality
  Finished module shall maintain its verticality not greater than the stipulated tolerance for PPVC.

• Bulging
  No bulging of all structural elements, this will decrease the stability of the structures.

• Position of Continuity
  It is significant to maintain the position of reinforcement continuity to increase the speed of installation of precast module.

• Location of Cast in items
  The location of the cast-in items shall be checked and verified prior to the casting to avoid a redo/rectify.

• Twisting of Module
  All precast module shall not be greater than the allowable tolerance of all corners. This will reflect to the installation with regards to level, alignment and verticality.

• Fire and Corrosion Protection
  Passive fire protection layer and corrosion protection layer for all structure steel members must be check and confirm to ensure the compliance to code.
10. CRITICAL INSPECTION AND QUALITY CHECK

10.2 MEP WORKS

- **Structural opening position and Dimension**
  
  This will not be less than the actual dimension of doors, windows and etc..

- **MEP opening**
  
  Shall be bigger than the actual size of the pipes.

- **Water tightness test**
  
  To ensure that pipe works are water tight before and after the architectural finishing works.

- **Pressure test**
  
  To ensure no leakage for pressurized pipe works.

- **Cable continuity test**
  
  Shall be carried out to ensure cable and wiring condition.

- **Earthing megger test**
  
  To be carried out after complete modules construction to ensure continuity of conductors for lightning protection.

- **Electrical phase check**
  
  Required to ensure load are distributed in accordance to design among phases.

- **Shaft leakage inspection**
  
  To be carried out in conjunction with water tightness test of vertical pipe shaft.
10. CRITICAL INSPECTION AND QUALITY CHECK

10.3 ARCHITECTURAL WORKS

- **Vertical and horizontal alignments**
  Shall incorporate from the given 1 meter datum and offset line before finishing works.

  *Figure : Alignment verification.*

- **Levelling**
  To ensure that the module is levelled and set before the start of the finishing works.

  *Figure : Levelling of module*

- **Lightweight Panel Installation and QC Check**
  This will be installed as per the approved materials and shop drawing. To adhere to approved method statement to ensure that the execution falls within the acceptable tolerance.

  *Figure : Lightweight Panel Installation*
10. CRITICAL INSPECTION AND QUALITY CHECK

10.3 ARCHITECTURAL WORKS (cont’)

- **Waterproofing Application and QC Check**
  
  Application of waterproofing shall be carried out by qualified waterproofing installer. To adhere to approved materials and method statement to ensure that the waterproofing are installed accordingly.

- **Water Ponding Test**
  
  Shall comply with the approved method statement.

- **Tiling Installation and QC Check**
  
  All materials and method statement as well as shop drawing shall approved by the relevant consultant/s. It is important to check the batch delivery to control the tonality of the tile. Only qualified tiler can install the tile.
10. CRITICAL INSPECTION AND QUALITY CHECK

10.3 ARCHITECTURAL WORKS (cont’)

- **Pull-Out Test**

  This will carried out by accredited laboratory.

  *Figure: Tile Adhesive Pull-Out test*

- **Spray Test**

  Shall comply with the approved method statement.

  *Figure: Spray Test*

- **Skim Coating Application and QC Check**

  All materials shall be approved as well as the method statement recommended by the manufacturer.

  *Figure: Skim Coat Application*

- **Vinyl Tile Installation and QC Check**

  All materials and method statement and shop drawing shall be approved by the relevant consultant/s.

  All materials and method statement shall be approved by the relevant consultant/s.

  *Figure: Vinyl Installation*
10. CRITICAL INSPECTION AND QUALITY CHECK

10.3 ARCHITECTURAL WORKS (cont’)

• Kitchen and Sanitary Wares Installation and QC Check

All materials, shop drawings and method statement shall be approved by the relevant consultant/s.

Figure : WC Installation

• Door and Window Installation and Inspection

All materials, shop drawing and method statement shall be approved by the relevant consultant/s.

Figure : QC check on Window Installation

• Railing Installation and Inspection

All materials, shop drawing and method statement shall be approved by the relevant consultant/s.

Figure : Railing Installation

• Painting Application and Inspection

All materials and method statement shall be approved by the relevant consultant/s.

Figure : Painting Application
10. CRITICAL INSPECTION AND QUALITY CHECK

10.4 QUALITY CHECKS

10.4.1 Reinforced Concrete PPVC Before Cast

- QC inspection on mould dimension and cleanliness
- Reinforcement Installation and QC Inspection
- QC Check on Mould Assembly and Closing of Mould
- Cast in Items Installation and QC Inspection
- QC inspection on concrete
- Casting
10. CRITICAL INSPECTION AND QUALITY CHECK

10.4 QUALITY CHECKS

10.4.2 Steel PPVC - Accuracy of Steel Carcass

QC inspection on WPS, WPQR, Welder Certificate, Welding Consumable and all other related items.

QC inspection on the dimension and accuracy of 2D and 3D jig.

Respective 2D frames are placed inside 3D jig, welded to form 3D carcass & QC Inspection.

Respective steel members are placed inside 2D jig, welded to form 2D frame & QC Inspection.

Trial stacking (in according to the actual position) at factory to ensure the accuracy of the steel carcass.

Proceed to Architectural Work.