

# BIP Application Checklist for Prefabricated Prefinished Volumetric Construction (PPVC) Systems

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## **Introduction:**

- a. *This BIP application checklist outlines the potential issues related to the adoption of innovation during project implementation stage. The checklist is not exhaustive, and agencies may raise additional queries during BIP evaluation*
- b. *To facilitate BIP evaluation, applicants are required to address to all issues in sections (A) to (G). All applications shall include the drawings, detailing, test reports, certificates, relevant approvals from overseas authorities, and other documentation of the proposed system covering sections (A) to (G) described below*
- c. *For non-residential PPVC systems, applicants are required to check with BIP Secretariat on the agencies' requirements to confirm scopes that are not relevant to non-residential projects*

## **(A) General**

1. Overview of the proposed system
  - 1.1. Construction cost
  - 1.2. Construction time & productivity improvement (*please request for the template from the BIP Secretariat*)
  - 1.3. Characteristics of the proposed system
  - 1.4. Manufacturing process in factory
  - 1.5. Method of assembly on site
  - 1.6. Project track records (both local and international, if any)

## **(B) Design & Construction (BCA)**

### **a. Structural Design**

1. Construction material – include material type, grade and dimension
2. QA/QC Inspection
  - 2.1. Off-site construction / production (local/overseas)
  - 2.2. On-site construction / installation
  - 2.3. Non destruction examinations
3. Structural design code & specification
4. Compliance with building control act & regulations and other international codes (show approvals from overseas authorities, where relevant)
5. Structural performance
6. Loading criteria – dead, live, earthquake and wind
7. Serviceability criteria - building lateral, deformation and vibration
8. Differential movement
9. Lateral stability
10. Corrosion protection (where relevant)
11. Architectural and structural plans to illustrate the proposed system (min. A3 drawing size)
12. Structural analysis simulation to be carried out for high-rise residential building (at least for 40-storey buildings) or low-rise non residential building (up to 5-storey building)

### **b. Prefabrication, Quality and Maintenance**

1. Details of module to module connections
  - 1.1. Method of ensuring alignment /evenness of different floor finishes across the modules, including the interface details of different floor finishes within the unit such as marble, tile and timber floorings
  - 1.2. Method of ensuring continuity of mechanical, electrical and plumbing (MEP) services across the modules

2. Method of preventing damage to finishes and fittings during storage, transportation and installation
3. Façade interfacing, types of façade available, constraints, cladding possibilities
4. Roofing interfacing, opportunities and constraints
5. Internal door interfacing
6. Areas and span of proposed system components
7. Provision of wall openings
8. Staircases material and its connection
9. Addressing water seepage concerns (Sealants with limited lifespan should not be used)
  - 9.1. From façade
  - 9.2. From roof
  - 9.3. Within modules (especially from wet areas)
  - 9.4. Between modules (Both horizontal and vertical)
  - 9.5. Method of water drain-off from the roof of PPVC module (To ensure water will not accumulate on the roof and potentially leak into the module)
10. Ensuring uniformity between on-site and off-site architectural works while joining modules. To show clearly how to address alignment and jointing between modules to ensure level floor finishes at the interface
  - 10.1. Consistency between on-site and off-site floor and wall finishes (example colour tonality)
  - 10.2. Uniformity of wall and ceiling finishing works (example painting)
11. To show method of sealing up gap below partition or internal wall, between modules interface
12. Long-term Performance
  - 12.1. Method of preventing architectural finishes from differential movement (example floor cracks)
  - 12.2. Protection of architectural finishes from deterioration over time
13. Mechanical & electrical works
  - 13.1. Shaft installation
  - 13.2. To indicate, on plan, the extent of MEP works that is installed in the modules off site (including equipment)
  - 13.3. Provide method of connection and typical detail of connection for MEP services between modules for works that will be done on site.
  - 13.4. Measures implemented to ensure enough working space for installation/ maintenance of services and equipment on site
14. The system for residential development shall be completed with architectural finishes for walls, floors and ceilings which are constructed and assembled in factory. The minimum level of off-site works for individual trades must comply with the requirements set out in the prevailing COP on Buildability
15. The system for residential development shall be completed with wardrobe and cabinets which are constructed and assembled in factory and must comply with the requirements set out in the prevailing COP on Buildability
16. The critical areas of individual components/trades in the system shall comply with the acceptable international and local standards, for example:
  - 16.1. Durability corrosion protection of structural steel through appropriate coating system or other equivalent method (such as providing additional sacrificial thickness of structural steel) shall be provided to ensure the continued safety of the building for its intended use;
  - 16.2. Internal wall partition strength must comply with SS492;
  - 16.3. Wet areas waterproofing must comply with CP82 and BCA's Good Industry Practices guide;
  - 16.4. Window water-tightness must comply with CONQUAS requirements.
17. The connection details for finishing, fittings, MEP services shall be provided, including the method of replacement in the future.
18. Building maintenance works
  - 18.1. Corrosion
  - 18.2. Façade cleaning
  - 18.3. Water leakage / waterproofing
  - 18.4. Crack line

**c. Inspection**

1. Access or specific methodologies to enable inspections of concealed key structural elements (such as in PPVC buildings) for the purpose of regular maintenance checks and structural inspection shall be provided in the design of the system.

**d. Household Shelter (HS) and Staircase Storey Shelter (SSS)**

*(for non-residential projects, please check with BIP Secretariat on the requirements for this section)*

1. HS and SSS shall be designed to comply with their latest technical requirements. This shall be stated in the BIP application.
2. The floor slab of the PPVC modules located in the HS/SSS setback distance envelop shall be constructed of normal weight reinforced concrete.
3. Volumetric precast hollow core shall be adopted in HS.
4. Precast staircase flight shall be adopted in SSS or alternatively adopt volumetric precast hollow core staircase storey shelter.
5. The followings shall be included in the BIP application:
  - 5.1 Floor layout plan showing the location of the Household Shelter (HS) and Staircase Storey Shelter (SSS) in relation to overall building layout plan shall be included.
  - 5.2 Sequence of construction of HS/SSS vis-a-vis installation of abutting PPVC modules.
  - 5.3 Proposed connection details between HS/SSS wall and abutting PPVC module and design calculations showing connection capacity is equivalent to that of the RC slab (with 2 layers of nominal reinforcements) connected to HS/SSS wall.

**e. In-Built Bathroom (IBB)**

1. In-Built Bathroom should follow the [Performance Requirements of the Prefabricated Bathroom Unit \(PBU\)](#) which specifies the following:
  - 1.1 Performance requirements for wall panels (including Appendix C or Appendix D appended in Annex)
  - 1.2 Access to utilities for maintenance, repair and replacement
  - 1.3 Allow for replacement of tiles
  - 1.4 Provision for barrier-free accessibility design requirements
  - 1.5 Affix a manufacturer's label
  - 1.6 Provide a homeowner user manual
  - 1.7 Drawings to reflect area of waterproofing application (Layouts, sectional details, and interfacing details)

**(C) Transportation & Logistics (LTA)**

1. Proposed Transportation Plan -
  - 1.1 Indicate route from factory to holding area/construction site and travel schedule
  - 1.2 State vehicle type, overall dimensions (width, rear overhang, length & height) and weight
  - 1.3 Refer to [LTA.PROMPT](#) for oversized vehicle movement (OVM) permit requirements
2. Lifting and Installation Method
  - 2.1 For the installation, to show clearly how to manage potential height restrictions and AMSL control, especially when the project site is under the flight path. To show that the crane used when lifting modules for installation does not extend into restricted air space.
3. Holding Areas - Proposed location to hold the proposed system (location to mark up on location map)
  - 3.1 The holding areas should be within development sites and lifting works should not affect public streets.

4. Road surface protection (where relevant) - Type of protection material and method to be clearly illustrated. For example, protection measures for the road bitumen surface.
5. Road signage relocation (where relevant)
  - 5.1 Type and quantity of affected signages
  - 5.2 New locations to house the affected signages must be clearly illustrated in the map and photographs.
6. To specify method of protecting modules, including protection for all internal fitting-out and finishes during transportation, lifting and installation
7. To specify/show the trailer dimensions and the model to be used for transportation for PPVC modules

## **(D) Management of Working & Design Risks (MOM)**

### **1. Risk Management**

- 1.1 An audit report with supporting documents from **a MOM-recognised WSH Auditing Organisation** on a document review of your risk assessments and safe work procedures related to PPVC activities in casting and fitting out factories (if located in Singapore) and in your clients' worksites, including but not limited to the following:
  - PPVC modules casting and fitting out factory plant layouts (if located in Singapore);
  - all dry and wet trades required for PPVC fabrication in casting and fitting out factories (if located in Singapore);
  - PPVC modules transportation;
  - PPVC modules storage;
  - PPVC modules lifting, shifting and installation arrangements;
  - access & egress onto & from PPVC modules;
  - lifting, rigging and guiding / restraint of PPVC modules;
  - working-at-height and fall prevention / protection of workers during PPVC activities during fabrication and installation;
  - positioning of workers during adjusting and installation of PPVC modules, etc.

#### Note:

- i. *Assessment should cover all work activities from when the PPVC module reaches the site by trailer, up till when the module is installed and unriggered.*
  - ii. *A bizSAFE audit report is not acceptable as it does not meet the requirements as stated in item 1.1.*
- 1.2 Your audit action plan and all necessary supporting documents/ photographic records to address and close the auditor's findings and recommendations from item 1.1.
  - 1.3 Certification of (minimum) bizSAFE Level 3.

### **2. Design for Safety (Dfs)**

As a designer/ supplier of PPVC modules, when your PPVC modules are supplied and used in a project as defined Workplace Safety and Health (Design for Safety) Regulations (Dfs Regulations), you are responsible to perform the duties of a Designer under the Dfs Regulations. The design of your proposed PPVC modules have a significant impact on the safety and health of workers, particularly to those who construct, maintain, repair, and eventually demolish or remove the building / structure. It is therefore important that safety and health are considered at the start of your design process.

Hence, you are required to submit the following:

- 2.1 the lifting and installation plan of your PPVC modules at your clients' worksites, highlighting your Dfs considerations, and detailing the following:
  - lifting equipment to be used (e.g. crane, lifting frame, chains, pulleys, loading platform, wheeled jack, lifting lugs built into the PPVC modules etc);

- relevant Professional Engineer's (PE) design and calculations (e.g. lifting frame, loading platform, lifting lugs etc);
  - rigging & load restraint methods;
  - plan view of all typical modules showing the locations of all lifting lugs, joints and connections for barricades in the same diagram to confirm that there are no clashes in position and confirmation whether these connections would be built-in or installed on site. (Note: the assessment of work activities would differ depending on the proposal);
  - schematic diagram showing the crane's lifting capacity over the project's layout relating to the PPVC modules' position and weight;
  - confirmation that safety buffer that would be applied above the SWL of the tower crane is more than 10%;
  - the tower crane's tie-back position in the simulated layout and notional details of the element of which the tie-back would be anchored to, and whether the element in question is able to take on the reaction loads from the tower crane including loads during lifting of the module;
  - summary table of all the dimensions and weights of all PPVC modules
- 2.2 A statement by a PE indicating that the lifting frame(s) used to lift the PPVC modules, and the lifting lugs built into the PPVC modules are
- (i) designed in accordance to an International Standard, and
  - (ii) has attained a minimum Factor of Safety of 3
- 2.3 Method Statement, for purpose of external works, on how plastering and finishes would be carried out (e.g. whether work platforms, safety screens, gondolas etc. would be used and details of the anchorage points for these platforms noting that hacking of the module for installation of anchorage points may not be an option).
- 2.4 A complete step-by-step pictorial SWP illustration of the entire process of the onsite PPVC module lifting, movement and installation.
- 2.5 An owner's manual on future PPVC related building maintenance, defect rectifications and demolition work processes.

## **(E) Bathroom, Sanitary & Water Services (PUB)**

### **1. Sanitary System**

***(for non-residential projects, please check with BIP Secretariat on the requirements for this section)***

- 1.1 The design of the sanitary work shall comply with the Sewerage and Drainage (Sanitary Work) Regulation and the code of practice for sewerage and sanitary work.
- 1.2 Mock-up Bathroom Drawing and Sectional Plan
- 1.3 Sanitary and Discharges Pipes Detail Plan
- 1.4 Floor-Trap Details. Please provide the options of two floor-trap systems, 1) Shallow Floor Trap 2) P or S-trap including their connection details to vertical stack.
  - 1.4.1 Shallow Floor Trap requirement:
    - 1.4.1.1 State the model no of Snow Brand shallow FT to be used
    - 1.4.1.2 To submit certificate of compliance EN1253-1, with test reports to be enclosed:
      - Anti-Blockage test
      - Water tightness test
      - Flow Rate Test
      - Odour tightness Test
      - Resistance of Water Seal to Pressure
      - Depth of Water Seal
      - Access for Cleaning
      - Self-cleansing capacity
      - Position of side inlet

1.4.2 On top of the requirement specified in EN1253, shallow floor trap are to be complied with the following requirements:

Descriptions	Standard Requirements
Depth of Water Seal	Min 50mm
Passage Clearance	Min 25mm
Outlet Diameter	Min 75mm
Floor Trap (Water Compartment)	Shall be integral type, removable trap is not allowed.
Floor Trap Grating and Anti-Mosquito Valve	Shall incorporate an approved type of floor trap grating and anti-mosquito valve
Service Plug in the Floor Trap (if provided)	To provide permanent instruction label to the service plug.

## 2. Water Service Installation

- 2.1 The design of the water service installation and the water service work shall comply with the Public Utilities (Water Supply) Regulations as well as the Singapore Standard CP48 - The Code of Practice for Water Services.
- 2.2 Water pipes and fittings to be used shall comply with the standards and requirements stipulated by PUB.

## (F) Fire Safety (SCDF)

1. Provision of documental proofs and detail drawings to illustrate compliance of fire code requirements of proposed system in terms of compartmentation, material usage, etc.
2. Mode of fire protection
3. Sectional plans to show the fire protection details and elements
4. Details on the use of plastic materials on or within floors, walls and ceilings, if any
5. Types and integrity of the fire rated board system
6. Fire safety review of the system conducted by fire safety engineer, where relevant
7. Fire test performance reports & certificates of conformity (COCs) for regulated fire safety products for building construction in Singapore
  - 7.1 The proposed building products/materials/systems shall comply with the fire test performance requirements stipulated in Annex B of Appendix 15 Fire Safety Guidelines for Certification of Regulated Fire Safety Products/Materials of the Fire Code.
  - 7.2 Fire test performance reports from test laboratories & certificates of conformity (COCs) for regulated fire safety products from certification bodies accredited by Singapore Accreditation Council (SAC) shall be provided for the proposed products/materials/systems.
    - 7.2.1 If overseas accredited testing laboratory recognised by SAC is engaged to conduct the fire performance tests for the proposed products/materials/systems, the test performance reports shall be certified by accredited certification bodies in Singapore before they can be used for building construction in Singapore.
    - 7.2.2 To avoid unnecessary delay of project completion, QPs shall engage the certification body and registered inspector (RI) earlier to conduct factory inspection at the overseas manufacturing plant for certification and conformity of regulated fire safety products/materials/systems.
8. Mock-up physical sample (1 no.) of proposed system, where relevant. Clear illustration of components of system to illustrate compliance of fire safety integrity and fire performance rating, if applicable.

**(G) Environmental (NEA)**

1. The system shall comply with the technical requirements and provisions stipulated in the following:
  - 1.1 Code of Practice on Environmental Health
  - 1.2 Singapore Standard SS 593: Code of Practice for Pollution Control
  - 1.3 Environmental Public Health Act, Environmental Protection and Management Act, and their attendant regulations, including the Environmental Protection and Management (Control of Noise at Construction Sites) Regulations.
- 2 Please specify noise control measure to keep noise within NEA's specified levels, especially for night works

## Appendix C :

### Test Reports for Panel Boards used as wall and floor of PBUs

<b>Product Name</b>	
<b>Manufacturer</b>	
<b>Type of Board</b>	
<b>Density (kg/m<sup>3</sup>)</b>	

#### Instructions

1. Unless otherwise stated, please conduct and submit test reports according to the test standards listed below.
2. All test reports shall be the original or certified true copies issued by local or overseas laboratories accredited to ISO/IEC 17025, SAC-SINGLAS and SAC-MRA<sup>Note 1</sup> within last 5 years.
3. The manufacturer of panel boards used in the PBU system shall establish a Quality Management System certified according to EN ISO 9001.

S/N	Test Standard	Criteria/Remarks
<b>A</b>	<b>Strength Performance</b>	
1.	<u>SS492:2001</u> Specification for performance requirements for strength and robustness (including methods of test) for partition walls	To achieve a grade of <b>Medium Duty (MD)</b> and above.
<b>B</b>	<b>Thermal Properties</b>	
2.	<u>BS 476 Part 21: 1987*</u> Fire tests on building materials and structures.	*Only applicable for single-slab PBU system
3.	<u>BS 476 Part 22: 1987*</u> Fire tests on building materials and structures.	*Only applicable for PBU wall system which is also used as party wall or compartment wall
4.	<u>BS 476 Part 4: 1970</u> Fire tests on building materials and structures. Non-combustibility test for materials	<b>Non-combustible</b>
5.	<u>EN 13501-1: 2007 +A1: 2009</u> Fire classification of construction products and building elements on flame spread and smoke density.	
<b>C</b>	<b>Acoustic Properties</b>	
6.	<u>ASTM E90: 2004</u> Standard test method for laboratory measurement of airborne sound transmission loss of building partitions and elements	
<b>D</b>	<b>Green Label and Mold Resistance</b>	



S/N	Test Standard	Criteria/Remarks
7.	<u>Singapore Green Building Product Labelling Scheme (SGBPLS)</u> Category: Panel Board	Panel board used in the PBU system must be certified under SGBPLS
8.	<u>ASTM D3273 – 12*</u> Standard test method for resistance to growth of mold on the surface of interior coatings in an environmental chamber	<b><u>To achieve a rating of 9 and above</u></b> *Test to be conducted on uncoated panel boards (e.g. without water proofing, paint, tiles etc)
<b>E</b>	<b>Physical and Moisture Related Properties</b>	
9.	<u>BS EN 12467: 2012*</u> Fibre-cement flat sheets – Product specification and test methods	*Test standards and requirements to adopt <b>Category A</b> unless otherwise stated
	a) Flexural strength (Bending strength) b)	
	c) Moisture movement	Value of <b><u>moisture movement to achieve <math>\leq 0.07\%</math></u></b>
	d) Water impermeability*	*For panel boards used as floor panels within the PBU system, please adopt a water height of 50mm above the sample panel board during the test
	e) Warm water*	* Please adopt a water bath in excess of lime for this test
	f) Heat-rain*	*Test to be conducted on uncoated panel boards (e.g. without water proofing, paint, tiles etc) for 50 cycles. Any additional material which appears on the back panel surface during the test should be sampled and tested for identification purpose
	g) Soak-dry*	*Test to be conducted on uncoated panel boards (e.g. without water proofing, paint, tiles etc) for 50 cycles
10.	<u>BS EN 317:1993</u> Particleboards and fibreboards – Determination of swelling in thickness after immersion in water	<b><u>Swelling in thickness to achieve <math>\leq 1.5\%</math></u></b>

*Note 1:* Singapore Accreditation Council (SAC) signs bilateral Mutual Recognition Arrangement (MRA) with other national accreditation bodies. It is a signatory to the International Laboratory Accreditation Cooperation (ILAC) Arrangement and regional cooperation bodies such as the Asia Pacific Laboratory Accreditation (APLAC).

## Appendix D : Test Reports for Lightweight Concrete Panels used as wall and floor of PBUs

Product Name	
Manufacturer	
Concrete Mix Raw Materials (No need to indicate proportion)	
Grade of concrete	
Density of concrete (kg/m <sup>3</sup> )	

### Instructions

- Unless otherwise stated, please conduct and submit test reports according to the test standards listed below.
- All test reports shall be the original or certified true copies issued by local or overseas laboratories accredited to ISO/IEC 17025, SAC-SINGLAS and SAC-MRA<sup>Note 1</sup> within last 5 years.
- The manufacturer of the lightweight concrete panels used in the PBU system shall establish a Quality Management System certified according to EN ISO 9001.

S/N	Test Standard	Criteria
<b>A</b>	<b>Strength Performance</b>	
1	<u>SS492:2001</u> Specification for performance requirements for strength and robustness (including methods of test) for partition walls.	To achieve a grade of <b>Medium Duty (MD)</b> and above.
<b>B</b>	<b>Fire Safety<sup>#</sup> and Thermal Properties</b>	
2.	<u>EN 13501-1: 2007 +A1: 2009</u> Fire classification of construction products and building elements on flame spread and smoke density.	As per the Section 3.15.19 of the <u>Code of Practice for Fire Precautions in Buildings 2018</u> available on the SCDF website.
3.	<u>BS EN 45545-2:2013+A1:2015</u> Toxicity emission of construction products and building elements.	
<p><sup>#</sup>The tests required for fire safety may vary according to the type and composition of lightweight concrete. As such, please be advised to consult SCDF on the necessary tests to be conducted. The consultation can be facilitated by the PBU screening panel secretariat after the submission of application.</p>		

C Physical and Moisture Related Properties		
4.	<p><u>BS EN 772-11:2011</u> Methods of test for masonry units Part 11: Determination of water absorption due to capillary action.</p>	<p><b><u>Coefficient of Water Absorption due to Capillary Action (<math>\text{g}/\text{m}^2 \cdot \text{s}^{0.5}</math>) should not exceed 30, 25 and 20</u></b> (rounded to nearest integer) at test duration of 10 minutes, 30 minutes and 90 minutes respectively.</p>
5.	<p><u>BS EN 772-1:2000</u> Methods of test for masonry units – Part 1: Determination of compressive strength*  *To adopt conditioning by immersion.</p>	<p><b><u><math>\geq 80\%</math> of mean declared value</u></b> (compressive strength in dry state, as tested in the normal cube strength test), accordance with EN 771-4.</p>
6.	<p><u>BS EN 12467: 2012*</u> Moisture resistance properties of material.  *Test standards and requirements to adopt <u>Category A</u> unless otherwise stated.</p>	
	<p>a) Water impermeability*</p> <p>*For panel boards used as floor panels within the PBU system, please adopt a water height of 50mm above the sample panel board during the test.</p>	<p>Traces of moisture may appear on the under face of the sheet, <b><u>but in no instance shall there be any formation of drops of water.</u></b></p>
	<p>b) Heat-rain*</p> <p>*Test to be conducted on uncoated panel boards (e.g. without water proofing, paint, tiles etc) for 50 cycles. Any additional material which appears on the back panel surface during the test should be sampled and tested for identification purpose.</p> <p>The same specimen is to be tested for water impermeability after the heat-rain test, in accordance with the test methods specified in the BS EN 12467.</p>	<p><b><u>No visible cracks, delamination, warping and bowing or other defects.</u></b></p> <p>Traces of moisture may appear on the under face of the sheet, <b><u>but in no instance shall there be any formation of drops of water.</u></b></p>

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