Design for Manufacturing and Assembly (DfMA) in Housing Construction

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Director,
Technology & Capability Department,
Building and Construction Authority
• BCA is statutory board under the Ministry of National Development of the Singapore Government.

**Mission**

“We shape a *safe, high quality, sustainable and friendly built environment*”
Outline

1. Industry Transformation Map (ITM)
2. Design for Manufacturing & Assembly (DfMA)
3. DfMA Technologies for Housing Construction
4. Challenges and Learning Points from DfMA Projects in Singapore
Design upfront for ease of manufacturing and assembly
• Highly automated offsite production facilities
• Efficient and clean on-site installation process

Integrated Digital Delivery (IDD)
• Enabled by Building Information Modelling
• Fully integrated processes and stakeholders
• Advanced info-communication technology

Green Buildings
• Design for Green Buildings
• Sustainable Practices in operation and maintenance

VISION
• Advanced and integrated Sector
• Progressive and Collaborative firms
• Good Jobs for Singaporeans
Design for Manufacturing and Assembly (DfMA)

Moving work offsite will improve **safety, productivity** and **quality**

- **Design for** Manufacturing (off-site and automation) and **Assembly** (on-site)

- Fewer workers on-site
- Better site safety
- Faster construction
- Fewer delivery trips
- Better quality control
- Lesser dust and noise
Target on DfMA Adoption Rate

*Note: % is based on GFA of the projects
Wide spectrum of DfMA technologies and supporting facilities

**Components:**
*Incremental Improvement*

- **Prefab Components**
  - Precast
  - ICPHs

- **Advanced Prefab Systems**
  - Structural Steel / Advanced Precast / Hybrid

- **Integrated Sub-assemblies**
  - Mass Engineered Timber (MET) / Hybrid

- **Fully Integrated Assemblies**
  - PPVC

**Integrated Assemblies:**
*Game-Changing Improvement*

- Prefab MEP Deck
- Prefab Module with Platform/ Catwalk

**Architectural**

- On-site Dry Applied Finishes
  - Drywall
  - Engineered timber floor
- Prefinished Surfaces
- Prefab kitchens/ Common Toilets

**MEP**

- Flexible Water Pipe/ Sprinkler Dropper
- Prefab Ceiling Module/ Prefab Plant
- Prefab MEP Deck

**Manpower Savings [Project Level]**
- 10%
- 20%
- 35%
- 40%

**Manpower Savings [Trade Level]**
- 30%
- 45%
- 60%
- 70%
DfMA Technologies for Housing Construction

- Precast Technology
- Prefabricated Bathroom Units (PBU)
- Prefabricated Prefinished Volumetric Construction (PPVC)
Precast concrete elements are produced by casting concrete in a reusable mold or “form” off-site and transported to the construction site for installation.

Why Precast?

✓ Time and manpower savings
✓ Higher quality finishes
80% of our residents stay in public housing, most adopt precast technology.
Prefabricated Bathroom Unit (PBU)

A prefabricated bathroom unit (PBU) refers to a bathroom unit preassembled off-site complete with finishes, sanitary ware, concealed pipes, conduits, ceiling, bathroom cabinets, shower screens and fittings before installing in position.

Why PBU?

✓ Time and manpower savings
✓ Higher quality finishes

Click for Video
Prefabricated Prefinished Volumetric Construction (PPVC)

Modules complete with internal finishes, fixtures and fittings are manufactured in factories and transported to site for installation in a Lego-like manner.

Why PPVC?

- Substantial quantum of reduction in on-site manpower
- Better construction environment
Types of PPVC

Concrete

Steel

Courtesy: Dragages

Courtesy: Moderna Homes
# Level of off-site finishes requirements for PPVC

<table>
<thead>
<tr>
<th>Element</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 &amp; Glazing</td>
<td>100%</td>
</tr>
<tr>
<td>Doors</td>
<td>100%, only door leaves allowed for on-site installation</td>
</tr>
<tr>
<td>Wardrobe and Cabinets</td>
<td>100%, only wardrobe and cabinet doors allowed for on-site installation</td>
</tr>
<tr>
<td>M&amp;E including water &amp; sanitary pipes, electrical conduits &amp; ducting</td>
<td>100%, only equipment and fixtures to allowed for on-site installation</td>
</tr>
<tr>
<td>Electrical sockets &amp; light switches</td>
<td>100%, only light fittings allowed for on-site installation</td>
</tr>
</tbody>
</table>
3-prong Approach for Establishing a Robust Ecosystem for DfMA

1. Generate Lead Demand
2. Build Up Supply Chain
3. Develop Industry Capabilities
Generating Demand in Singapore

1. Public sector development
   - Public sector to take the lead in *DfMA method of construction*

2. Private sector development
   - Stipulate *PPVC method of construction through Government Land Sales*
   - *Incentivize firms to adopt technologies and improve capabilities*
Projects Adopting PPVC in Singapore

PPVC

- 42 projects
  (7 completed, 35 on-going)
- Development types:
  Hostel, Nursing Home, Hotel, Dormitory, Residential, Industrial, Commercial etc.

10-Storey Crowne Plaza Hotel Extension
Completed in 2016

9-Storey Woodlands Care Home
Completed in 2017

13-Storey NTU Nanyang Crescent Hostel
Completed in 2017

12-Storey Wisteria Commercial & Condominium
Completed in 2018

40-Storey Clement Canopy Condominium
To be completed in 2019

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PPVC Projects in Singapore

Completed, 35 On-going

7 Completed, 35 On-going

Probably the most number of volumetric projects in the world!
Bringing in Productive Technologies – Building Innovation Panel (BIP) for PPVC

Inter-Agency Building Innovation Panel (BIP)

Building Innovation Panel (BIP)
- Ensuring design complies with regulatory requirements

PPVC Manufacturer Accreditation Scheme (MAS)
- Ensuring high quality in PPVC production

First in the World
In Principle Acceptance (IPA)

<table>
<thead>
<tr>
<th>S/N</th>
<th>Supplier / Manufacturer</th>
<th>BIP In Principle Acceptance (IPA)</th>
<th>PPVC Manufacturer Accreditation Scheme (MAS)</th>
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<tbody>
<tr>
<td>1</td>
<td>Excel Precast Pte Ltd</td>
<td>BIP2016-01-0024.pdf</td>
<td>Yes (Part 1: Provisional Certificate)</td>
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<td>2</td>
<td>SFP System Pte Ltd</td>
<td>BIP2016-01-0025.pdf</td>
<td>Pending</td>
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<tr>
<td>3</td>
<td>Integrated Precast Solutions Pte Ltd</td>
<td>BIP2016-04-0239.pdf</td>
<td>Yes (Full Accreditation)</td>
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<td>4</td>
<td>Vico Construction Pte Ltd</td>
<td>BIP2016-05-0042.pdf</td>
<td>Pending</td>
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<td>5</td>
<td>Dragagri Pte Ltd</td>
<td></td>
<td></td>
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<tr>
<td>6</td>
<td>Prefab</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>CS Corp Pte Ltd</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Mod Pre</td>
<td></td>
<td></td>
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<tr>
<td>9</td>
<td>Qingjie</td>
<td></td>
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<tr>
<td>10</td>
<td>Sambroc</td>
<td></td>
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<tr>
<td>11</td>
<td>China C</td>
<td></td>
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<tr>
<td>12</td>
<td>HL Bulk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>G &amp; W</td>
<td></td>
<td></td>
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<tr>
<td>14</td>
<td>Surway</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Modern</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Robin V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>NAM Modular</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>URA</td>
<td></td>
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Note: This list is subject to change and may not be exhaustive.
## Building Innovation Panel (BIP)

<table>
<thead>
<tr>
<th>Agencies</th>
<th>Items</th>
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<tbody>
<tr>
<td>A. BCA</td>
<td>Design and Construction</td>
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<tr>
<td>B. LTA</td>
<td>Transportation and Logistics</td>
</tr>
<tr>
<td>C. MOM</td>
<td>Worksite Safety &amp; Lifting</td>
</tr>
<tr>
<td>D. PUB</td>
<td>Bathroom, Sanitary &amp; Water Services</td>
</tr>
<tr>
<td>E. SCDF</td>
<td>Fire Safety</td>
</tr>
<tr>
<td>F. NEA</td>
<td>Environmental</td>
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</tbody>
</table>

**PPVC Checklist**

To facilitate BIP evaluation, 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.

### (A) General
1. Overview of the proposed system
   1.1. Construction cost
   1.2. Construction time & productivity improvement (pls request the template from the 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)
BIP Approved PPVC Systems

Number of Systems (Cumulative)

- **Steel PPVC**
  1. Unitized Building
  2. Moderna Homes
  3. Sembcorp EOSM
  4. AM Modular
  5. CIMC
  6. Tiong Seng
  7. Dragages
  8. Mod Prefab
  9. TTJ
  10. Quicksmart
  11. TK Modular
  12. Imax
  13. Lightrus

- **Concrete PPVC**
  1. Integrated Precast
  2. SPP System
  3. Excel Precast
  4. Vico
  5. Dragages
  6. Mod Prefab
  7. Prefab Tech
  8. CS Corp & ICPH
  9. Qingjian
  10. Sembcorp EOSM
  11. China Con
  12. Sunway Concrete
  13. HL Building
  14. G & W Precast
  15. Moderna Homes
  16. Robin Village
  17. Nakano
Develop Industry Capabilities for PPVC and Prefabricated MEP

First in the World

Published in April 2018!

Published in Oct 2017!

Available on the web (Free download)

BIP

Courses on DfMA

Seminars and Workshops on DfMA

Guidebooks on DfMA

Project Sharing

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PPVC Projects in Singapore

**NTU North Hill Hostel**

- **Number of Storeys**: 13 (6 blocks)
- **Number of Rooms**: 1580
- **Number of Modules**: 1200

**Crowne Plaza Extension**

- **Number of Storeys**: 10
- **Number of Rooms**: 243
- **Number of Modules**: 252
**PPVC Projects in Singapore**

<table>
<thead>
<tr>
<th>Project Information</th>
<th>NTU Nanyang Crescent Hostel</th>
<th>MOHH Nursing Home</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Storeys</td>
<td>11 to 13 (4 blocks)</td>
<td>9</td>
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<tr>
<td>Number of Rooms</td>
<td>1527</td>
<td>180</td>
</tr>
<tr>
<td>Number of Modules</td>
<td>784</td>
<td>343</td>
</tr>
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**NTU Nanyang Crescent Hostel**

First PPVC Nursing Home in the region

**MOHH Nursing Home**
PPVC Projects in Singapore

Brownstone EC @ Canberra

<table>
<thead>
<tr>
<th>Project Information</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Storeys</td>
<td>10/12 (8 blocks)</td>
</tr>
<tr>
<td>Number of Units</td>
<td>638</td>
</tr>
<tr>
<td>Number of Modules</td>
<td>4384</td>
</tr>
</tbody>
</table>
Crowne Plaza at Changi Airport

- 10 Storey Hotel
- 243 Guest Rooms
- Steel PPVC
- 252 Modules

Simple case study of steel PPVC project with video

Copyright © Building and Construction Authority
The Clement Canopy

Simple case study of concrete PPVC project with video

Project Information

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<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Number of Storeys</td>
<td>40</td>
</tr>
<tr>
<td>Number of Units</td>
<td>505</td>
</tr>
<tr>
<td>Number of Modules</td>
<td>1866</td>
</tr>
</tbody>
</table>

Photo Courtesy: Dragages (Singapore)
Challenges and Learning Points from DfMA Projects in Singapore

1. Industry mind-set change
2. Design freeze
3. Early Contractor Involvement
4. Synchronization of production, logistics and site coordination
5. Progress payment for offsite construction
Change the way We Build!

BCA will continue to lead the built environment sector in changing the way we build by driving the adoption of DfMA to meet current and future challenges.
Thank you!