

Design for Manufacturing and Assembly (DfMA) for High-rise and High-density Cities — Challenges and the Way Forward

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Rapid Urbanisation and Increasing Manpower Squeeze

“If we are to reduce our dependence on foreign workers without sacrificing high economic growth, we have no choice but to speed up the pace of automation and mechanization.”

–Minister for Finance and Trade and Industry, 1984 Annual Budget Statement, Singapore

**Construction Workforce Level in 2009:
> 360,000**



Tightening of foreign labour pool



Construction Industry – the need for a Paradigm Shift

A huge number of foreign workers



Labour Intensive Construction Methods



Pressing need to transform the industry towards high productivity, quality and safety

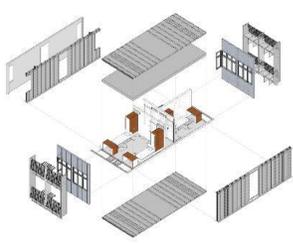
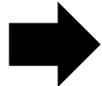
Reduce Dependency on Onsite Workers

The Need for A Paradigm Shift

Design for Manufacturing and Assembly (DfMA)



Typically messy site with various trades



Design for

Manufacturing
(off-site and automation)

and **Assembly**
(on-site)

Changing The Way We Build

DfMA Continuum

Components:
Incremental Improvement

Integrated Assemblies:
Game-Changing Improvement

Prefab Components

Advanced Prefab Systems

Integrated Sub-assemblies

Fully Integrated Assemblies

Precast



10%

Structural Steel / Advanced Precast / Hybrid



20%

Mass Engineered Timber (MET) / Hybrid



35%

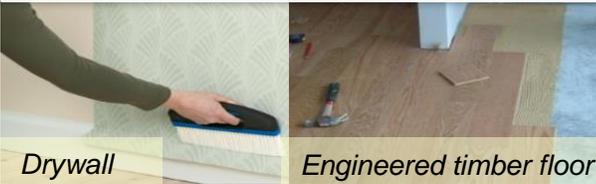
Prefabricated Prefinished Volumetric Construction (PPVC)



40%

Manpower Savings [Project Level]

On-site Dry Applied Finishes



30%

Prefinished Surfaces



45%

Prefab Bathroom Unit (PBU)



PBU

Prefab kitchens/ Common Toilets



Common Toilet

Kitchen

60%

PPVC



70%

Manpower Savings [Trade Level]

Flexible Water Pipe/ Sprinkler Dropper



Prefab Ceiling Module/ Prefab Plant



Prefab Plant

Prefab MEP Deck



Prefab Module with Platform/ Catwalk



PPVC

Structural

Architectural

MEP

COMPLETED

PPVC Project Highlights

Changi Airport Crowne Plaza Hotel

- Time savings of 3 months;
- On-site **manpower savings 44%**

10 storeys completed in 26 days

Transport trips reduced by 70%



Video: OUE & Dragages

COMPLETED

PPVC Project Highlights

Clement Canopy Condominium

World's tallest Concrete PPVC building
(40 storeys)



Superstructure
completed in 14 months



Image & video: OUL & Dragages

Changing The Way We Build - Singapore's move towards DfMA

Wide range of DfMA projects



Project Information

Steel PPVC

Gross Floor Area (GFA)	48,500 m ²
Number of Storeys	11 to 13 (4 blocks)
Number of Rooms	1527
Number of Modules	784

Project Information

MET

Gross Floor Area (GFA)	9,800 m ²
Number of Storeys	3

Project Information

MET/ Structural Steel/ Prefab MEP

Gross Floor Area (GFA)	19,800 m ²
Number of Storeys	5 (2 blocks)

Changing The Way We Build - Singapore's move towards DfMA

Wide range of DfMA projects

COMPLETED



Woodlands Nursing Home

COMPLETED



Global Switch Data Centre

ON-GOING



BCA Academy Phase 2

Project Information

Steel PPVC

Gross Floor Area (GFA)	9,000 m ²
Number of Storeys	9
Number of Units	180
Number of Modules	343

Project Information

Prefab MEP

Gross Floor Area (GFA)	25,000 m ²
Number of Storeys	6
Number of MEP Modules	337

Project Information

PPVC/ MET/ Prefab MEP

Gross Floor Area (GFA)	26,000 m ²
Number of Storeys	<ul style="list-style-type: none"> • 7-storey ZEB • 16-storey SLEB

Rising Trend in Site Productivity 2009-2018

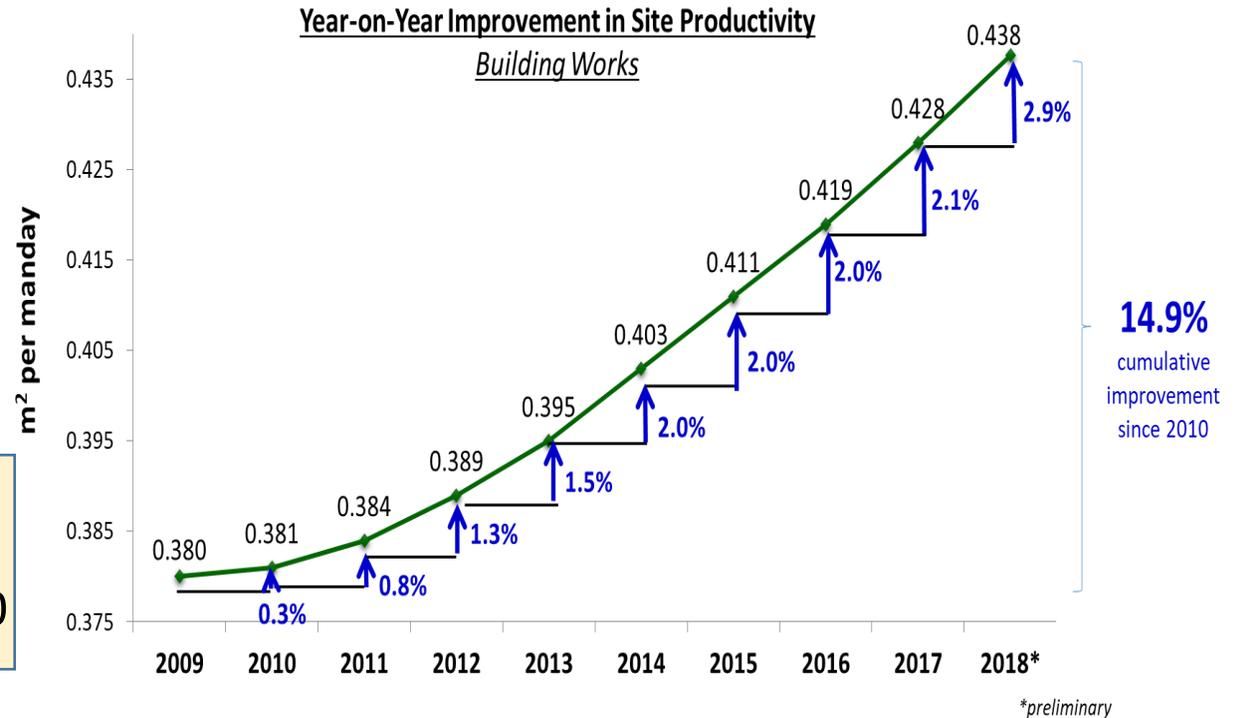
Target

To achieve at least 20% productivity improvement by 2020

Progress and Achievement

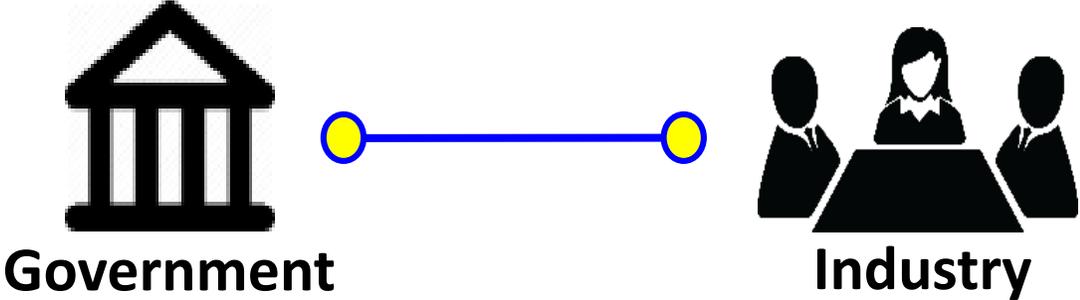
✓ About 14.9%* productivity improvement since 2010

* Preliminary figure

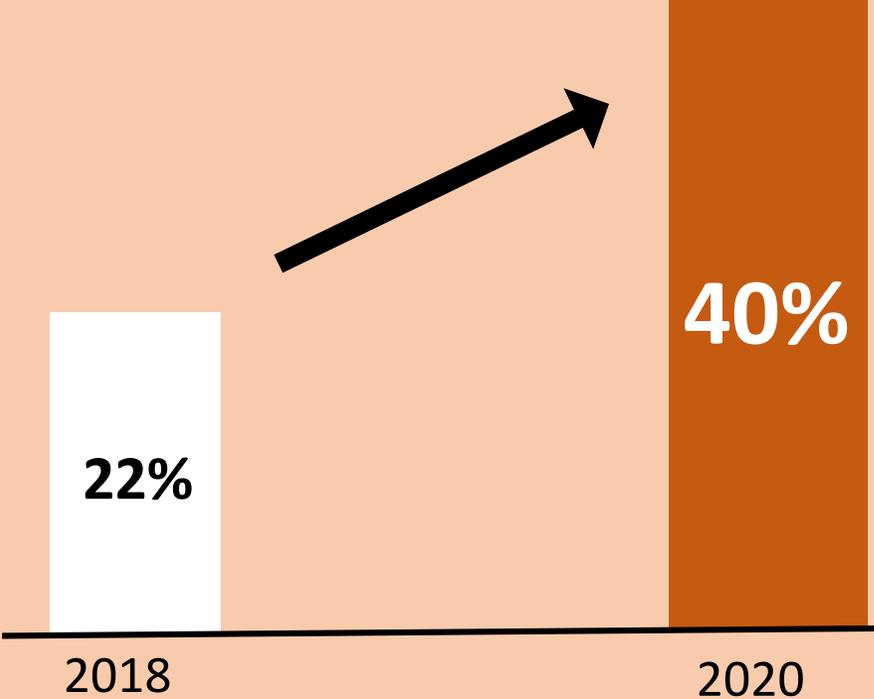


Site productivity - floor area completed per manday

Changing The Way We Build



Target: **40% DfMA adoption** by 2020



DfMA adoption rate

1 Government Walking the Talk

Public Sector Taking the Lead

Adoption of DfMA technologies (Singapore)

PPVC (25 projects)



NTU Hostel

Prefab MEP (7 projects)



Healthcare Hub

MET (14 projects)



Sport Hall

Structural Steel (12 projects)



State Court

Creating the Demand for DfMA

Specifying DfMA technology adoption for Singapore's Government Land Sales (GLS) sites since 2014



PPVC

29 GLS sites
(24 residential, 4 mix developments, 1 hotel)



**Structural Steel /
Minimum Prefab Level**

2 Commercial GLS and **50**
Industrial GLS sites

1 Government Walking the Talk

Creating the Supply for DfMA – Integrated Construction and Prefabrication Hubs (ICPHs)



Jalan Gali Batu

Pulau Punggol Barat (PPB)

Pulau Punggol Timor (PPT)



●	Completed ICPH
●	ICPH under planning

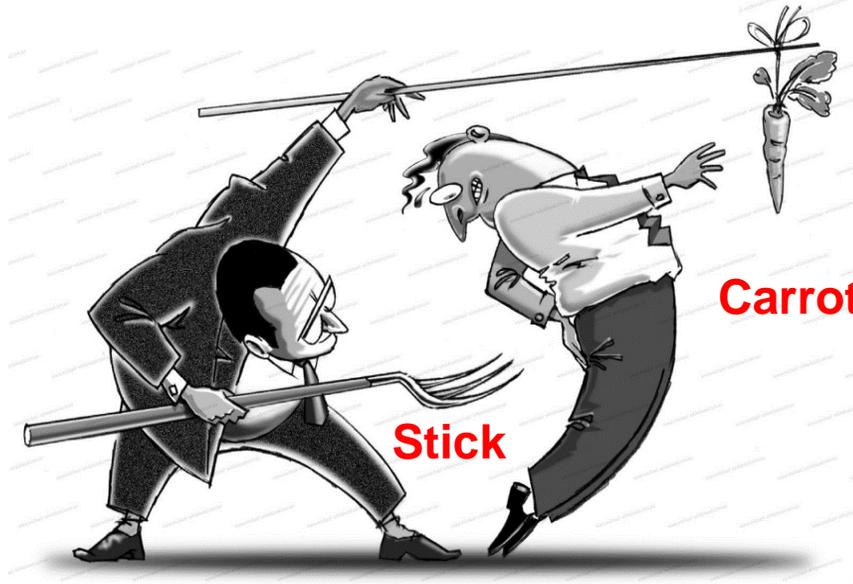
2 The “Carrot and Stick” Approach

Carrot and Stick Approach

Mandatory Requirements



- Buildability legislation
 - Constructability Score
 - Buildability Score



Incentive Funding



- Public Sector Construction Productivity Fund (PSCPF)
 - S\$154 million
- Construction Productivity and Capability Fund (CPCF)
 - ~S\$800 million
- Bonus GFA scheme

3 Driving and Facilitating Innovation

Building Innovation Panel (BIP)

A One-Stop Multi-Agency Platform for All Innovative Construction Technologies to secure Speedy Clearance of All Regulatory Requirements

Building and Construction Authority

MND
SINGAPORE

(Co-chairs)



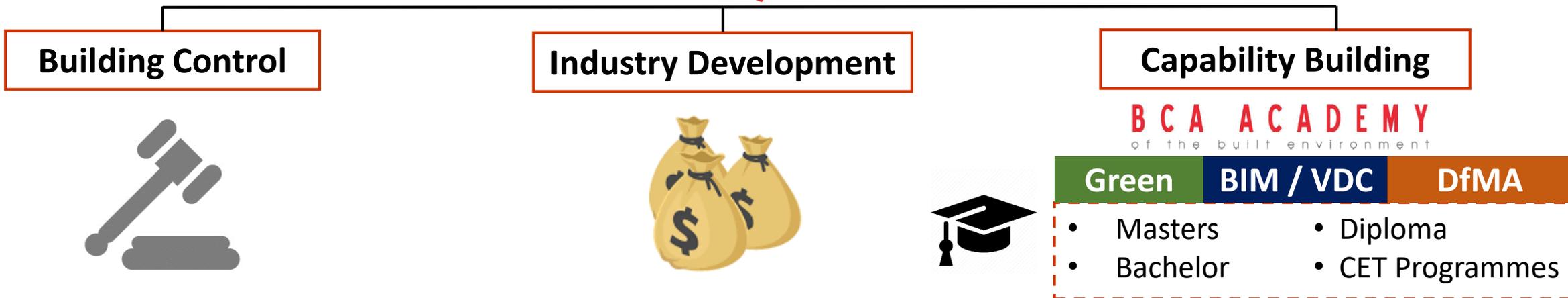
Total of fast-tracked in-principle approvals:

- **33 PPVC systems**
- **Approved MET as a construction material in Singapore**

4 Building Capability

Training for Transformative Skills

Building and Construction Authority



Institutes of Higher Learning:



Training Area	Current <i>(Personnel trained by BCAA)</i>	Target: 2025
Green Design and Engineering	9,850	25,000
Integrated Digital Delivery	11,600	20,000
DfMA	7,900	35,000



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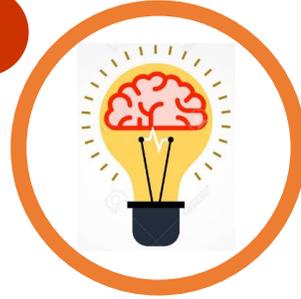
Government
Walking the Talk

2



Carrot and Stick

3



Driving for Innovation

4



Building Capability

Mindset change towards DfMA –
Point of No Return



DfMA

– the Way Forward for A Future-Ready and Technologically Advanced Built Environment Sector