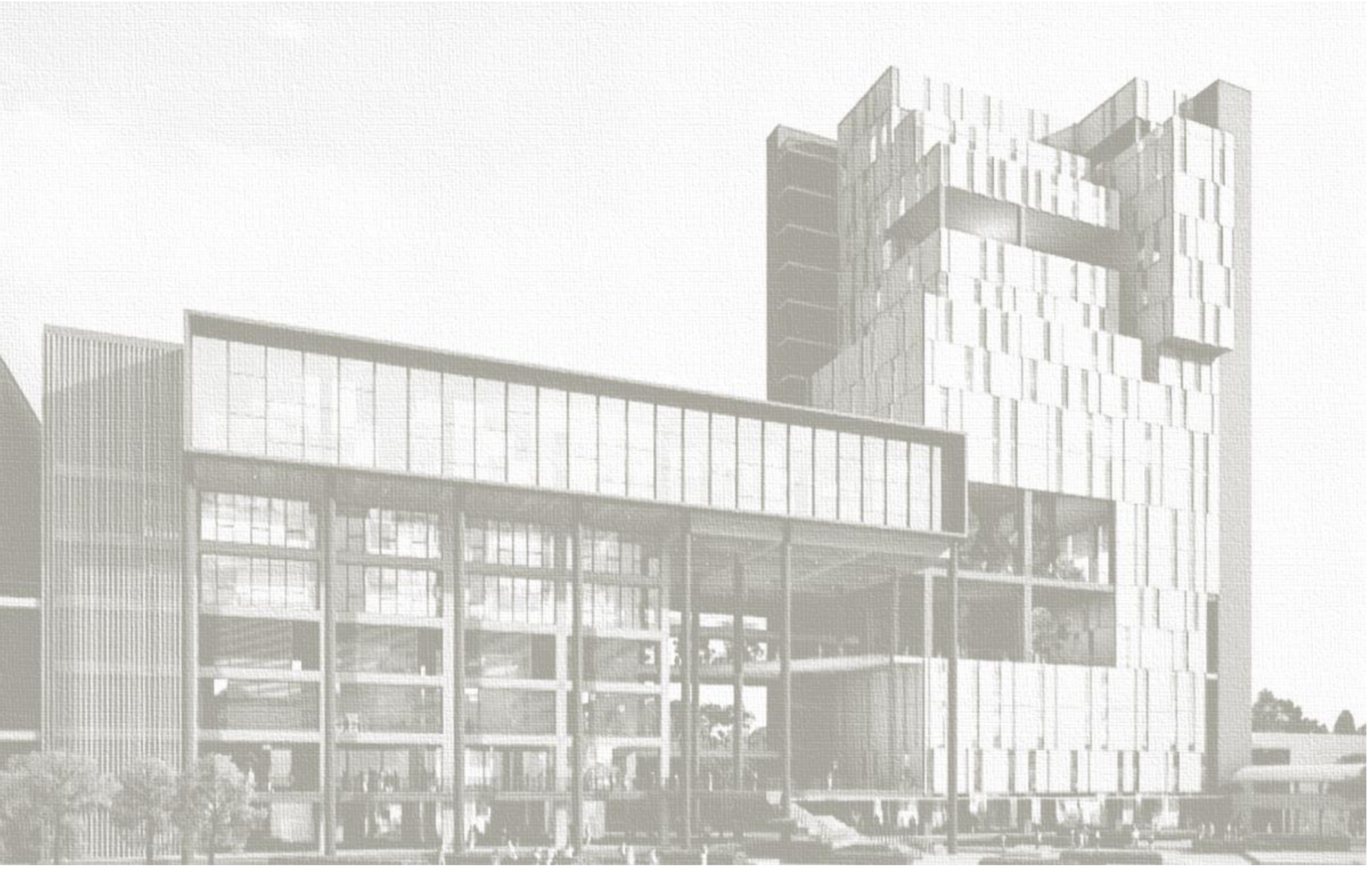
Building and Construction Authority



Code of Practice on

BUILDABILITY

2022 Edition

The Code of Practice on Buildability is electronically published by the Building and Construction Authority.

Contents

CODE OF PRACTICE

ANNEX

Introduction

Since 2001, BCA had implemented the buildability legislation for building projects to raise productivity in the built environment sector and reduce its reliance on foreign workers. The legislation encourages architects and engineers to work together to deliver buildable designs to facilitate more productive construction downstream.

In 2011, BCA introduced the constructability requirements for builders to adopt more labour-efficient technologies and methods to improve productivity during construction. This helps to ensure that productivity concepts initiated during the upstream design phase by architects and engineers would be implemented with labour-saving construction processes by builders during the downstream construction phase.

To accelerate the built environment sector's productivity improvement, besides raising the minimum standards for Buildable Design Score and Constructability Score progressively, mandatory adoption of key productivity components including industry-wide standard dimensions and building components for specific types of development have been introduced since 2014. Specific productive technologies are also stipulated as land sales conditions for developments sold under the Government Land Sales (GLS) Programme. This helps to pave the way for the industry to adopt the Design for Manufacturing and Assembly (DfMA) approach, by moving as much construction work off-site to a controlled manufacturing environment as possible and minimising work on site.

Since December 2020, the buildability legislative framework has been revamped to make DfMA an integral part of the way buildings are designed and built. A DfMA component has been included for each discipline of Structural, Architectural and Mechanical, Electrical and Plumbing (MEP) works.

To encourage innovation and provide flexibility for designers to propose different design solutions to meet the productive outcomes as intended by the Buildability requirements, BCA has also introduced outcome-based options as alternative for projects to meet the legislated minimum standards.

This Code sets out the requirements of minimum Buildable Design Score, minimum Constructability Score, outcome-based solutions and specific productive technologies stipulated for GLS sites. It also sets out the submission procedures and the method of determining the Buildable Design Score and the Constructability Score of projects. Some amendments and revisions may be expected from time to time.

If you need clarification on any aspect of this Code of Practice, please contact the Building and Construction Authority, Singapore.

1 SCOPE

This Code sets out the requirements of minimum Buildable Design Score, minimum Constructability Score and outcome-based solutions for buildings, the method for determining the Buildable Design Score and the Constructability Score as well as their submission procedures. It also sets out the requirements for the specific productive technologies which need to be complied with by developments built on Government Land Sales sites for which the technologies have been stipulated as land sales conditions.

2 DEFINITIONS

For the purpose of this Code, the following definitions shall apply:

Alternative Solution	An outcome-based solution that facilitates innovation at the design and construction stages and achieves productivity outcome. The outcome-based solution refers to any one of the deemed acceptable solutions that meets the high prefabrication requirements or an open solution that adopts innovative design and construction techniques that meets productivity improvement requirements as set out in Annex C. Alternative or outcome-based solutions are applicable only to developments with Gross Floor Area ≥ 25,000 m^2.
Buildability	The extent to which the design of a building facilitates ease of construction as well as the extent to which the adoption of construction techniques and processes affects the productivity level of building works.
Buildable Design Score	The score for buildable design computed in accordance with the Buildable Design Appraisal System (BDAS) as set out in the Code of Practice.
Buildability Detailed Design and Implementation Plan	Documents including plans which describe and define the type, extent of use and details of the building systems, building components, buildable features and Design for Manufacturing and Assembly (DfMA) technologies to be implemented for the building works for the purpose of computing the Buildable Design Score.
Constructability Score	The score for constructability computed in accordance with the Constructability Appraisal System (CAS) as set out in the Code of Practice.

Constructability Implementation Plan	Documents including plans which describe and define the type, extent of use and details of the construction techniques, processes, plant, equipment and innovative methods and systems to be implemented for the building works for the purpose of computing the Constructability Score.
Deemed Acceptable Proposal	A proposal which describes and demonstrates the extent of use of prefabrication technologies to be implemented for the building works for the purpose of meeting the prefabrication requirements stipulated in any one of the deemed acceptable solutions as set out in Annex C.
Deemed Acceptable Solution	One of the outcome-based solutions with high prefabrication requirements available for developments with Gross Floor Area ≥ 25,000 m² as an alternative for Qualified Persons and builders to meet the minimum Buildable Design Score and minimum Constructability Score requirements. A submission of a deemed acceptable solution has to be accompanied by a Deemed Acceptable Proposal. A development with Gross Floor Area ≥ 25,000 m² adopting a deemed acceptable solution and submitting a Deemed Acceptable Proposal need not comply with the minimum Buildable Design Score and minimum Constructability Score requirements.
Government Land Sales Programme	A programme under which State land for private sector development is sold via public tender by the Government or a statutory board acting as an agent for the State.
Gross Floor Area	The gross floor area is calculated using the definition by the Urban Redevelopment Authority (URA).
Minimum Buildable Design Score for Superstructure Works	The lowest Buildable Design Score allowed for the superstructure works under a particular category of development and gross floor area stipulated in this Code.
Minimum Buildable Design Score for Basement Works	The lowest Buildable Design Score allowed for the basement works (including first storey) under a particular category of development and gross floor area stipulated in this Code.
Minimum Constructability Score	The lowest Constructability Score allowed for the relevant gross floor area of the development stipulated in this Code.

Open Solution	One of the outcome-based solutions available for developments with Gross Floor Area ≥ 25,000 m^2 as an alternative for Qualified Persons and builders to meet the minimum Buildable Design Score and minimum Constructability Score requirements. Qualified Persons and builders submitting an open solution must demonstrate that the adoption of innovative design and construction techniques for the building works are able to meet the stipulated productivity improvement requirements as set out in Annex C. The proposal for the open solution has to be submitted in the form of a Project Productivity Improvement Plan for BCA's approval. A development with Gross Floor Area ≥ 25,000 m^2 adopting an open solution and submitting a Project Productivity Improvement Plan need not comply with the minimum Buildable Design Score and minimum Constructability Score requirements.
Professional Engineer (PE)	A registered professional engineer as defined in the Professional Engineers Act 1991
Project Productivity Improvement Plan	A plan of the building works which describes the extent of use and details of the innovative designs and construction techniques to be implemented for the building works for the purpose of demonstrating that the stipulated productivity improvement requirements under the open solution can be achieved.
Qualified Person (QP)	The Qualified Person shall be as defined in the Building Control Act, Chapter 29, Part I, Section 2.
Type of Use	This refers to the use of the building/development, e.g. residential use or commercial use.
Type of Building Work	This refers to new building work, repairs, alterations or additions to an existing building (whether carried out within or outside the existing building).

3 STATUTORY REQUIREMENTS

3.1 Act and Regulations

The following Act and Regulations have relevance:

a. The Building Control Act.

b. The Building Control Regulations.

c. The Building Control (Buildability and Productivity) Regulations.

3.2 Responsibility

3.2.1 It is the responsibility of the developers, architects, engineers, builders and others engaged in the design and construction of buildings to be conversant with the statutory requirements pertaining to the Buildability Framework. Designers and builders should familiarise themselves with the Buildable Design Appraisal System (BDAS) and Constructability Appraisal System (CAS) respectively to enable them to consider a wider range of construction systems, methods, technologies, materials and products to meet the requirement for minimum Buildable Design Score and Constructability Score. They should also be familiar with the requirements for outcome-based solutions (deemed acceptable solutions and open solution) should they choose to adopt any of them instead of complying with the minimum legislated scores for their developments.

3.2.2 The developer shall engage the appropriate Qualified Persons (QPs) and Professional Engineers (PEs) to carry out buildable design. The QP for Architectural Works, the QP for Structural Works, the PE for Mechanical Works and the PE for Electrical Works shall be responsible for ensuring that the Buildable Design Score requirement is met. Where applicable, the QPs and PEs shall also be responsible for ensuring that the mandatory buildable systems and standard dimensions/components as set out in Annex A – Sections 2 to 6 are adopted for the building works; and that the high impact productive technologies imposed on developments under the Government Land Sales (GLS) Programme as set out in Annex A – Section 7 are adopted and have met the minimum requirements. The QPs and PEs shall jointly declare the Buildable Design Score achieved. The QPs and PEs shall also jointly declare the Buildable Design Score achieved for the building works as completed (referred to as the record plans of Buildable Design Score).

3.2.3 The builder shall be responsible for ensuring that the Constructability Score requirement is met. The builder shall declare the Constructability Score achieved. The builder shall also declare on the Certificate of Compliance of Constructability Score.

3.2.4 Where an outcome-based solution is adopted, the QPs, the PEs and the builder shall be responsible for ensuring that the requirements for DfMA or high prefabrication level together with system formwork or the productivity improvement outcome, as the case may be, are met.

4 CATEGORIES OF BUILDINGS

The various types of building development are categorised in Table A. Buildings listed under the First Schedule are exempted from both the buildable design and constructability requirements.

Table A Categories of Building

CATEGORIES	TYPES OF DEVELOPMENT
Public Residential (non-landed)	• Flat
Private Residential (non-landed)	• Condominium • Flat • Service apartment • Apartment • Dormitory • Hostel
Commercial	• Bank • Departmental store • Shopping centre • Office building • Supermarket • Restaurant • Hotel • Conventional hall and facilities • Exhibition hall
Industrial	• Factory • Warehouse • Brewery • Cold storage building • Packaging and processing plant • Printing plant
Institutional, School and others	• Primary school • Secondary school • Library • Hospital • Home for the aged • Childcare centre/Nursery • Research building

Table A **Categories of Building** ***(continued)***

CATEGORIES	TYPES OF DEVELOPMENT
Institutional, School and others	• Educational facilities • Terminal building • Campus • Medical centre • Camp • Embassy • Museum • Crematorium and Columbarium • Club house • Cinema/Theatre • Sports/Recreational facilities • Public transport station
MRT station	• Above ground station • Underground station

The above list shall not be exhaustive. The QP/PE/Builder is advised to seek clarification with BCA if his type of development is not stated in the above list.

5 BUILDABLE DESIGN SCORE REQUIREMENTS

5.1 Buildable Design Score

5.1.1 The Buildable Design Scores of the superstructure and basement works (where applicable) of a building design shall be determined using this Code of Practice and the Buildable Design Appraisal System (BDAS) which is given in Annex A of this Code. BDAS may, from time to time, be amended, modified or replaced with a new edition.

5.1.2 Summary of the four areas of scoring

The Buildable Design Score of a project is made up of 4 parts:

Part 1 - Structural System. Points are awarded for the use of various types of structural system, Design for Manufacturing and Assembly (DfMA) technologies in the structural discipline and structural buildable design features.

Part 2 - Architectural System. Points are awarded for the use of various types of wall system, architectural finishes, DfMA technologies in the architectural discipline and architectural buildable design features.

Part 3 - Mechanical, Electrical and Plumbing (MEP) System. Points are awarded for the use of various types of MEP system, DfMA technologies in the MEP discipline and MEP buildable design features.

Part 4 - Innovation and Others. Points are awarded for the use of new innovative systems and technologies that can achieve manpower savings of at least 20%.

In addition to the above, points are awarded for simple designs that help to ease construction, design modularisation that ease manufacturing, and standardisation and repetition of components under Part 1, 2 and 3.

5.1.3 The maximum Buildable Design Score achievable for a project is capped at 120 points. Depending on the category of a building, the maximum point weightage for Part 1, 2, 3 and 4 are as shown in Table B.

Table B Point Weightages for Different Categories of Building

<table>
<tr><th rowspan="2">CATEGORY OF BUILDING WORK / DEVELOPMENT</th><th colspan="4">POINT WEIGHTAGE</th></tr>
<tr><th>Structural</th><th>Architectural</th><th>MEP</th><th>Innovation and Others</th></tr>
<tr><td>Public Residential (non-landed)</td><td>45 points</td><td>40 points</td><td>15 points</td><td rowspan="6">20 points</td></tr>
<tr><td>Private Residential (non-landed)</td><td>35 points</td><td>45 points</td><td>20 points</td></tr>
<tr><td>Commercial</td><td>35 points</td><td>30 points</td><td>35 points</td></tr>
<tr><td>Industrial</td><td>50 points</td><td>25 points</td><td>25 points</td></tr>
<tr><td>Institutional, School and others</td><td>35 points</td><td>30 points</td><td>35 points</td></tr>
<tr><td>MRT Station</td><td>50 points</td><td>25 points</td><td>25 points</td></tr>
</table>

5.2 Types of Development

5.2.1 The minimum Buildable Design Score requirements for superstructure and basement works (where applicable) shall apply to new building works with Gross Floor Area (GFA) equals to or greater than 5,000 m^2.

5.2.2 The minimum Buildable Design Score requirements shall also apply to building works consisting of repairs, alterations and/or additions (A&A work) to an existing building if the building works involve the construction of new floor and/or reconstruction of existing floor for which their total gross floor area is 5,000 m^2 or more.

5.2.3 For buildings not listed in the First Schedule, the QP/PE may apply for exemption if the building has a uniqueness arising from special functional requirements. The exemption will be on a case-by-case basis. The application for exemption is to be submitted to the Commissioner of Building Control.

5.3 Minimum Buildable Design Score

5.3.1 For new building works and A&A works outside existing building (considered as new work) which are submitted for planning permission on or after 30th April 2022, the minimum Buildable Design Scores for the superstructure and basement works (where applicable) for each category of development, namely residential projects, commercial projects, industrial projects, institutional, school and other projects, and MRT station projects are tabulated in Table C and Table D respectively. A building design with basement works is required to comply with both the Buildable Design Score for superstructure works and the minimum Buildable Design Score for basement works.

5.3.2 Different minimum Buildable Design Score requirements for superstructure works are given for 5,000 $m^2 \leq$ GFA < 25,000 m^2 and GFA $\geq$ 25,000 m^2.

Table C Minimum Buildable Design Score for Superstructure of All New Building Works and MRT Stations

CATEGORY OF BUILDING WORK / DEVELOPMENT	MINIMUM BUILDABLE DESIGN SCORE FOR SUPERSTRUCTURE WORKS	
	5,000 m^2 ≤ GFA < 25,000 m^2	GFA ≥ 25,000 m^2
Public Residential (non-landed)	68	80
Private Residential (non-landed)	68	80
Commercial	60	70
Industrial	65	70
Institutional, School and others	60	66
MRT Station	60	

* *The minimum scores above are based on date of planning submissions made to URA including for building works built on land sold under the Government Land Sales (GLS) Programme.*

Table D Minimum Buildable Design Score for Basement of All New Building Works

CATEGORY OF BUILDING WORK / DEVELOPMENT	MINIMUM BUILDABLE DESIGN SCORE FOR BASEMENT WORKS
	GFA ≥ 5,000 m^2
Public Residential (non-landed)	42
Private Residential (non-landed)	
Commercial	
Industrial	
Institutional, School and others	
MRT station	

* *The minimum scores above are based on date of planning submissions made to URA including for building works built on land sold under the GLS Programme.*

5.3.3 For A&A work within existing buildings, the minimum Buildable Design Scores for residential, commercial, industrial, institutional, school and others and MRT station projects are shown in Table E.

Table E Minimum Buildable Design Score for A&A Work

CATEGORY OF BUILDING WORK / DEVELOPMENT	MINIMUM BUILDABLE DESIGN SCORE
Public Residential (non-landed)	42
Private Residential (non-landed)	
Commercial	
Industrial	
Institutional, School and others	
MRT station	

5.3.4 For clarity, reference shall be made to the table below for the relevant issue of Code of Practice to be used.

Table F Code of Practice to be used

DATE OF PLANNING APPLICATION	CODE OF PRACTICE TO BE USED
Before 1st January 2001	Not applicable
1st January 2001 – 31st July 2002	Code of Practice on Buildable Design *December 2000 edition*
1st August 2002 – 31st December 2003	Code of Practice on Buildable Design *June 2002 edition*
1st January 2004 – 31st August 2005	Code of Practice on Buildable Design *January 2004 edition*
1st September 2005 – 14th July 2011	Code of Practice on Buildable Design *September 2005 edition*
15th July 2011 – 31st August 2013	Code of Practice on Buildability *April 2011 edition*

Table F Code of Practice to be used *(continued)*

DATE OF PLANNING APPLICATION	CODE OF PRACTICE TO BE USED
1st September 2013 – 31st October 2014	Code of Practice on Buildability *2013 edition*
1st November 2014 – 30th November 2015	Code of Practice on Buildability *2014 edition*
1st December 2015 – 30th April 2017	Code of Practice on Buildability *2015 edition*
1st May 2017 – 14th December 2019	Code of Practice on Buildability *2017 edition*
15th December 2019 – 27th December 2020	Code of Practice on Buildability *2019 edition*
28th December 2020 – 29th April 2022	Code of Practice on Buildability *2020 edition*
On or after 30th April 2022	Code of Practice on Buildability *2022 edition*

5.3.5 Minimum Buildable Design Score for Mixed Development

The minimum Buildable Design Score for a mixed development will be pro-rated according to the GFA of each type of development. For example, the minimum Buildable Design Score for a mixed development comprising 70% private residential (non-landed) and 30% commercial is computed as follows:

Table G Computation of Minimum Buildable Design Score for a Mixed Development with GFA between 5,000 m² and 25,000 m²

CATEGORY OF BUILDING	% OF BUILDING GFA	MINIMUM BUILDABLE DESIGN SCORE FOR SUPERSTRUCTURE WORKS
		5,000 m² ≤ GFA < 25,000 m²
Private Residential (non-landed)	70% of GFA	70% of 68 = 47.60
Commercial	30% of GFA	30% of 60 = 18.00
The required minimum Buildable Design Score	100% of GFA	**66** **(rounded to nearest integer)**

Table H Computation of Minimum Buildable Design Score for a Mixed Development with GFA 25,000 m² and above

CATEGORY OF BUILDING	% OF BUILDING GFA	MINIMUM BUILDABLE DESIGN SCORE FOR SUPERSTRUCTURE WORKS
		GFA ≥ 25,000 m²
Private Residential (non-landed)	70% of GFA	70% of 80 = 56.00
Commercial	30% of GFA	30% of 70 = 21.00
The required minimum Buildable Design Score	100% of GFA	**77**

5.3.6 Minimum Buildable Design Score for Project with A&A Work

The minimum Buildable Design Score for a project with A&A work to be carried out both within and outside the existing building will be pro-rated according to the GFA of new work outside the existing building and work within the existing building. For example, the minimum Buildable Design Score for an A&A commercial project comprising 20% work within the existing building and 80% new work outside the existing building is computed as follows:

Table I Computation of Minimum Buildable Design Score for an A&A Commercial Project with GFA between 5,000m² and 25,000m²

TYPE OF WORK	% OF GFA	MINIMUM BUILDABLE DESIGN SCORE
		5,000 m² ≤ GFA < 25,000 m²
A&A work within existing building	20% of GFA	20% of 42 = 8.40
Work outside existing building	80% of GFA	80% of 60 = 48.00
The required minimum Buildable Design Score	100% of GFA	**56 (rounded to nearest integer)**

6 SUBMISSION PROCEDURES FOR BUILDABLE DESIGN SCORE REQUIREMENTS

Buildable Design Score and the Buildability Detailed Design and Implementation Plan are requirements for Building Plan (BP) approval. The BP will not be approved if the submitted Buildable Design Scores for both the superstructure and basement works (where applicable) are lower than the stipulated minimum. The Buildable Design Scores and the Buildability Detailed Design and Implementation Plan are to be submitted by QPs and PEs at the following stages:

- BP stage
- ST (Structural plan) basement and super-structural stage
- Temporary Occupation Permit (TOP)/Certificate of Statutory Completion (CSC) stage

For building works which the QPs and the PEs are adopting an outcome-based option in lieu of meeting the minimum Buildable Design Score, please refer to Annex C for the submission procedures.

6.1 Submission at BP Stage

The QP shall indicate in Form BCA-BP-BPAPPV01 (Application for Approval of Building Plans) whether Buildable Design Score calculations are applicable to the proposed building works. If applicable, the Buildable Design Scores for both superstructure and basement works are to be submitted together with the BP submission using Form BPD_BS01. The Buildable Design Scores are to be jointly declared by the QP for Architectural Works, the QP for Structural Works, the PE for Mechanical Works and the PE for Electrical Works and the detailed computation of the Buildable Design Scores shall be attached. Forms BCA-BP-BPAPPV01 and BPD_BS01 can be downloaded from BCA's website at https://www1.bca.gov.sg/.

In addition to the above, the QPs and the PEs must submit a Buildability Detailed Design and Implementation Plan jointly declared by the QP for Architectural Works, the QP for Structural Works, the PE for Mechanical Works and the PE for Electrical Works for approval. This plan serves to substantiate the computation of the Buildable Design Scores for the building works and shall include the following:

- the floor plan of every storey including the basement and roof which clearly marks out the structural floor area for every structural system, wall length for every wall system, wall length for every wall finish, area for every floor and ceiling finish, qualifying and prefabricated area of Mechanical, Electrical and Plumbing (MEP) system of that storey, extent of Design for Manufacturing and Assembly (DfMA) technologies and buildable features adopted, as well as any applicable pre-requisite item;

- the elevation plans and sectional plans which clearly mark out the types of structural system, wall system, wall finish, MEP system, DfMA technologies, pre-requisite items and buildable features to be constructed for the building works; and

- where applicable, the dimensions of building components and the extent of standardisation, the type and extent of repetition of prefabricated components, the connection and details of prefabricated components, the details of prefabricated reinforcement and the locations as well as the details of all DfMA technologies, pre-requisite items and buildable features to be constructed for the building works etc.

6.2 Submission at ST Basement and Super-structural Stage

The current submission procedures allow the ST to be submitted separately from the BP. Where ST submission is made before BP submission, the QP shall indicate in Form BCA-BE-STAPPV01 (Application for Approval of Structural Plans) whether Buildable Design Score calculations are applicable to the proposed building works. If applicable, the Structural Buildable Design Scores for both basement works (where applicable) and superstructure works are to be submitted by the QP for Structural Works at the ST basement and superstructural stage using Form BPD_BS01. The Structural Buildable Design Scores are to be jointly declared by the QP for Architectural Works, the QP for Structural Works, the PE for Mechanical Works and the PE for Electrical Works. Forms BCA-BE-STAPPV01 and BPD_BS01 can be downloaded from BCA's website at https://www1.bca.gov.sg/.

In addition to the above, the QP must submit a Buildability Detailed Design and Implementation Plan relating to the structural elements of the building works for approval. This plan must be jointly declared by the QP for Architectural Works, the QP for Structural Works, the PE for Mechanical Works and the PE for Electrical Works and serves to substantiate the computation of the Structural Buildable Design Scores for the building works and shall include the following:

- the floor plan of every storey including the basement and roof which clearly marks out the structural floor area for every structural system of that storey, the extent of DfMA technologies and buildable features adopted, as well as any applicable pre-requisite item;

- the elevation plans and sectional plans which clearly mark out the types of structural system, DfMA technologies, pre-requisite items and buildable features to be constructed for the building works; and

- where applicable, the dimensions of building components and the extent of standardisation, the type and extent of repetition of prefabricated components, the connection and details of prefabricated components, the details of prefabricated reinforcement as well as the locations and details of all DfMA technologies, pre-requisite items and buildable features to be constructed for the building works etc.

6.3 Departure and Deviation from Approved Buildability Detailed Design and Implementation Plan

If there are any deviations to the type or extent of coverage of structural system, architectural system, MEP system, DfMA technologies and buildable features including the dimensions of building components, repetition of building components etc. which affect the approved Buildability Detailed Design and Implementation Plan and the Buildable Design Scores submitted for the building works, the QP for Architectural Works, the QP for Structural Works, the PE for Mechanical Works and the PE for Electrical Works are required to submit an amended Buildability Detailed Design and Implementation Plan for approval. The QPs and PEs are also required to re-compute and submit the revised Buildable Design Scores which must not be lower than the stipulated minimum scores. Both the amended Buildability Detailed Design and Implementation Plan and the revised Buildable Design Scores are to be jointly declared by the QP for Architectural Works, the QP for Structural Works, the PE for Mechanical Works and the PE for Electrical Works.

6.4 Submission at TOP/CSC stage

6.4.1 Upon project completion, the QP for Architectural Works, the QP for Structural Works, the PE for Mechanical Works and the PE for Electrical Works shall compute and declare the Buildable Design Scores of the building works as completed (referred to as the record plans of Buildable Design Scores) and submit one set of the computation to BCA using Form BPD_BS03. The submission must be accompanied by a Buildability Detailed Design and Implementation Plan of the completed building works to support the computation of the Buildable Design Scores of the building works as completed and must be jointly declared by the QP for Architectural Works, the QP for Structural Works, the PE for Mechanical Works and the PE for Electrical Works. This submission is to be made before a temporary occupation permit or in a case where no such permit is earlier applied for, a certificate of statutory completion can be granted. Form BPD_BS03 can be downloaded from BCA's website at https://www1.bca.gov.sg/.

6.4.2 BCA may conduct site checks during the construction stage.

7 CONSTRUCTABILITY SCORE REQUIREMENTS

7.1 Constructability Score

7.1.1 The Constructability Score of the building works shall be determined using this Code of Practice and the Constructability Appraisal System (CAS) which is given in Annex B of this Code. CAS may, from time to time, be amended, modified or replaced with a new edition.

7.1.2 Summary of the three areas of scoring

The Constructability Score of a project is made up of 3 parts:

Part A - Structural System (maximum 60 points). Points are awarded for various methods and technologies adopted during the construction of structural works.

Part B - Architectural, Mechanical, Electrical & Plumbing (AMEP) System (maximum 45 points). Points are awarded for various methods and technologies adopted during the construction of AMEP works.

Part C - Good Industry Practices (maximum 15 points). Points are awarded for good industry practices adopted on site to improve productivity.

In addition to the above, points are obtainable in Part A and Part B if a project adopts innovative systems that help to achieve productivity improvement. Innovation points are awarded subjected to BCA's assessment on a case-by-case basis of the impact on labour efficiency of the particular system used.

The total points allocated under the CAS is 120 points.

7.2 Types of Development

7.2.1 The minimum Constructability Score requirement shall apply to new building works with Gross Floor Area (GFA) equals to or greater than 5,000 m^2.

7.2.2 The minimum Constructability Score requirement shall also apply to building works consisting of repairs, alterations and/or additions (A&A work) to an existing building if the building works involve the construction of new floor and/or reconstruction of existing floor for which their total gross floor area is 5,000 m^2 or more.

7.3 Minimum Constructability Score

7.3.1 The minimum Constructability Score for each category of development, namely residential projects, commercial projects, industrial projects, institutional, school and other projects comprising buildings of more than 6 storeys high which are submitted for planning permission on or after 30th April 2022 are tabulated in Table J.

7.3.2 For developments comprising buildings of 6 storeys and below which are submitted for planning permission on or after 30th April 2022, the minimum Constructability Scores are tabulated in Table K.

7.3.3 Different minimum Constructability Score requirements are given for 5,000 $m^2 \leq$ GFA < 25,000 m^2 and GFA $\geq$ 25,000 m^2. In addition to meeting the minimum Constructability Score requirements, projects must also achieve a minimum score under the Structural System component of the CAS as shown in Table J and Table K.

Table J Minimum Constructability Score for All Building Works comprising Buildings more than 6 Storeys and MRT Stations

CATEGORY OF BUILDING WORK / DEVELOPMENT	MINIMUM CONSTRUCTABILITY SCORE	
	5,000 $m^2 \leq$ GFA < 25,000 m^2	GFA $\geq$ 25,000 m^2
Public Residential (non-landed)	50 (Min 35 points from Structural System)	60 (Min 45 points from Structural System)
Private Residential (non-landed)		
Commercial		
Industrial		
Institutional, School and others		
MRT station		

* *The minimum scores above are based on date of planning submissions made to URA including for building works built on land sold under the GLS Programme.*

Table K **Minimum Constructability Score for All Building Works comprising Buildings of 6 Storeys and below**

CATEGORY OF BUILDING WORK / DEVELOPMENT	MINIMUM CONSTRUCTABILITY SCORE	
	5,000 m^2 ≤ GFA < 25,000 m^2	GFA ≥ 25,000 m^2
Public Residential (non-landed)	50 (Min 32 points from Structural System)	60 (Min 42 points from Structural System)
Private Residential (non-landed)		
Commercial		
Industrial		
Institutional, School and others		

* *The minimum scores above are based on date of planning submissions made to URA including for building works built on land sold under the GLS Programme.*

7.3.4 For clarity, reference shall be made to the table below for the relevant issue of Code of Practice to be used.

Table L **Code of Practice to be used**

DATE OF PLANNING APPLICATION	CODE OF PRACTICE TO BE USED
Before 15th July 2011	Not applicable
15th July 2011 – 31st August 2013	Code of Practice on Buildability *April 2011 edition*
1st September 2013 – 31st October 2014	Code of Practice on Buildability *2013 edition*
1st November 2014 – 30th November 2015	Code of Practice on Buildability *2014 edition*
1st December 2015 – 30th April 2017	Code of Practice on Buildability *2015 edition*
1st May 2017 – 14th December 2019	Code of Practice on Buildability *2017 edition*
15th December 2019 – 27th December 2020	Code of Practice on Buildability *2019 edition*

Table L Code of Practice to be used *(continued)*

DATE OF PLANNING APPLICATION	CODE OF PRACTICE TO BE USED
28th December 2020 – 29th April 2022	Code of Practice on Buildability *2020 edition*
On or after 30th April 2022	Code of Practice on Buildability *2022 edition*

8 SUBMISSION PROCEDURES FOR CONSTRUCTABILITY SCORE REQUIREMENTS

8.1 Submission of Constructability Score

The builder is required to submit the Constructability Score which shall not be lower than the stipulated minimum at either one of the following stages:

- at the time of application for permit to carry out structural works (Permit), or
- within 3 months (for non-Design and Build projects) or 6 months (for Design and Build projects) after the permit has been issued in the event that the builder requires more time to plan for the type of construction methods and technologies to be adopted in the project.

For building works adopting an outcome-based option, please refer to Annex C for the submission procedures.

8.1.1 Submission at Permit Stage

The builder shall indicate in Form BCA-BE-PERMIT (BEV/B1) (Joint Application for Permit to Carry out Structural Works) whether Constructability Score calculations are applicable to the proposed building works. If applicable, the Constructability Score is to be submitted together with the permit application using Form BEV_CS01. The Constructability Score for the proposed building works and the detailed computation of the Constructability Score is to be declared by the builder. Forms BCA-BE-PERMIT (BEV/B1) and BEV_CS01 can be downloaded from BCA's website at https://www1.bca.gov.sg/.

In addition to the above, the builder must submit a Constructability Implementation Plan of the building works with the Constructability Score calculations. This plan serves to substantiate the computation of the Constructability Score for the building works and shall include the following:

- the floor plan of every storey including the basement and roof, as well as the elevation plans and sectional plans which clearly mark out the types of construction techniques and processes, plant, equipment, innovative methods and systems and materials used for that storey or building; and

- details on the extent of adoption of each construction technique, process, plant, equipment, innovative method and system or material etc.

8.1.2 Submission within 3 months/6 months after Permit Issuance

The builder shall indicate in Form BCA-BE-PERMIT (BEV/B1) that the Constructability Score calculations, where applicable for the proposed building works, would be submitted within the timeframe allowed depending on the type of contract for the building works.

The Constructability Score and the detailed computation of the Constructability Score as declared by the builder shall be submitted using Form BEV_CS01, and is to be accompanied by the Constructability Implementation Plan of the building works as described in 8.1.1 above.

8.2 Departure and Deviation from Adopted Construction Methods and Technologies

If there are any deviations to the submitted Constructability Score due to changes to the type of construction methods and technologies adopted, the builder shall re-compute the Constructability Score resulting from such changes and submit the revised Constructability Score and the revised Constructability Implementation Plan at least 3 working days before the deviations are carried out at site. The re-submission of the Constructability Score shall be made using Form BEV_CS01 and the revised Constructability Score shall not be lower than the stipulated minimum.

8.3 Submission of Certificate of Compliance of Constructability Score

8.3.1 Upon completion of the building works, the builder shall submit a Certificate of Compliance of Constructability Score using Form BPD_CCS01 declaring that the construction of the building works has been carried out such that the Constructability Score of the building works is not less than the stipulated minimum Constructability Score. This submission is to be made before a temporary occupation permit or in a case where no such permit is earlier applied for, a certificate of statutory completion can be granted.

8.3.2 BCA may conduct site checks during the construction stage.

9 OTHER REQUIREMENTS

9.1 Site Records

The builder is required to submit to BCA the following documents and records as evidence to demonstrate compliance with the minimum Constructability Score requirement. The submission shall be made at every 3-monthly interval after the grant of the permit to carry out structural works till completion of the building works:

- a progress report on the types of construction methods, technologies and processes adopted for the building works in accordance with the Constructability Score and Constructability Implementation Plan submitted, including photographs evidencing the adoption of such construction methods, technologies and processes;
- records of the construction processes put in place for the building works; and
- any other documents, reports and records showing the details of the construction methods and technologies adopted.

The builder is also required to keep and maintain the above documents and records on site.

9.2 Construction Productivity Data

With DfMA becoming the mainstream way of construction, more on-site construction works would be shifted off-site. To enhance data collection and facilitate overall productivity measurement of the building works, the builder is required to:

- install and operate a biometric authentication system at the project site to collect the Construction Productivity Data of the building works; and
- submit both on-site and off-site Construction Productivity Data to BCA.

The Construction Productivity Data shall include but is not limited to:

- manpower utilisation (e.g. mandays required to carry out building works including prefabrication works);
- construction output (e.g. volume of precast components); and
- documentation relating to the construction of the building works.

Such Construction Productivity Data shall be submitted to BCA on a monthly basis which would be used to assess the overall productivity level of the building works.

First Schedule

BUILDING WORKS WHICH ARE NOT SUBJECT TO THE MINIMUM BUILDABLE DESIGN SCORE AND CONSTRUCTABILITY SCORE REQUIREMENTS

The types of development which are not subject to the minimum Buildability requirement are:

(a) any culvert, bridge, underpass, tunnel, earth retaining or stabilising structure, slipway, dock, wharf or jetty;

(b) any theme park;

(c) any place of worship;

(d) any power station; or

(e) any waste processing or treatment plant.

Annex A

BUILDABLE DESIGN APPRAISAL SYSTEM

1 INTRODUCTION

The Buildable Design Appraisal System or BDAS was developed by the Building and Construction Authority as a means to measure the potential impact of a building design on the usage of site labour. The appraisal system results in a 'Buildable Design Score' of the building design. A design with a higher Buildable Design Score will yield more efficient labour usage during construction and therefore result in higher site labour productivity.

1.1 Objective

The objective of BDAS is to result in the wider use of buildable designs. It is not the intention to adopt buildability at the expense of good architectural design. The need for more varieties and architectural features to satisfy clients' needs is recognised. There are, in fact, many examples of attractive designs that have high Buildable Design Scores.

Neither is the BDAS intended to solely promote DfMA technologies or prefabrication. Although, in general, prefabrication should give higher Buildable Design Scores, designs using simple cast-in-place construction can also yield reasonably high Buildable Design Scores.

Most importantly, buildable designs will lead to improvements in quality. This is due to the relative ease of construction and the need for fewer skilled tradesmen.

1.2 Principles of Buildable Design

The designer should first consider external factors such as soil condition, access and storage at the site, availability of resources, skills and technology, sequence of operations etc., to determine the most appropriate building system to be used. He can then apply the **3S** principles of *Standardisation, Simplicity* and *Single integrated elements* to achieve a buildable design.

Standardisation refers to the repetition of grids, sizes of components and connection details. A repeated grid layout, for example, will facilitate faster construction irrespective of whether formwork or prefabricated components are used. Similarly, columns or external claddings of repeated sizes will reduce the number of mould changes whether on-site or in the factory.

Simplicity means uncomplicated building construction systems and installation details. Use of DfMA technologies or prefabricated components and mechanical connections reduces many trade operations on site and should improve site productivity provided the principles of standardisation are observed.

Single integrated elements are those that combine related components together into a single element that may be prefabricated in the factory and subsequently installed on site. Prefabricated Prefinished Volumetric Construction (PPVC) modules and Prefabricated bathroom units (PBU) are good examples of this.

1.3 Scope

BDAS therefore looks at the design and computes the extent to which the principles of standardisation, simplicity and single integrated elements are found. It covers the structural systems, major architectural components such as external and internal wall systems, doors and windows, as well as MEP systems.

Points are awarded based on the types of structural, architectural and MEP system used. More points are awarded to the more buildable systems. The points are totaled to give the “Buildable Design Score” of the design.

1.4 Buildable Design Score and Contractor’s Productivity

The particular Buildable Design Score for a design does not imply that every contractor will achieve the same level of site productivity when building that design. There are other factors that affect the contractor’s output such as his management, quality of his sub-contractors etc. However, a high Buildable Design Score will imply that the same contractor should build that project with less site labour than one with a low Buildable Design Score.

1.5 Rationale on Allocation of Points

The computation of Buildable Design Score for a project involves the summation of Buildable Design Score attained for structural systems, architectural systems, MEP systems and buildable features. Buildable features include items contributing to design simplicity, modularisation and standardisation. The maximum Buildable Design Score achievable for a project is 120 points.

The allocation of points to structural systems, architectural systems, MEP systems and buildable features is based on manpower consumption. In certain instances, lower points are given to discourage the use of labour-intensive elements or components.

The points allocated to each building system and buildable feature will be updated regularly to reflect changes in technology.

1.6 Development of BDAS

The Buildable Design Appraisal System was developed with the assistance of a committee comprising leading local and foreign contractors who provided productivity data inputs from their projects. Inputs from various government agencies, consultants and product manufacturers were also incorporated. The concern for buildability, or the need to integrate design with construction, has also been taken up in developed countries. In Japan, this integration is maximised as most projects proceed on a design-and-build basis. Major Japanese contractors such as Takenaka Corporation, Taisei Corporation and Kajima Corporation have developed their own in-house buildability appraisal systems. BCA’s Buildable Design Appraisal System is modelled after Takenaka’s system.

1.7 Updates

This Code of Practice on Buildability, 2022 Edition, has included a number of updates.

1.7.1 Requirement for Professional Engineers (PEs) for Mechanical and Electrical Works to jointly declare Buildability submissions with QPs for Architectural Works and Structural Works

With the Buildable Design Appraisal System placing more emphasis on Mechanical, Electrical and Plumbing (MEP) works, PEs for Mechanical and Electrical Works now play a bigger role to influence the design of MEP systems. To foster greater collaboration across the various disciplines of work during upstream design stage, the PE for Mechanical Works and the PE for Electrical Works are now required to jointly declare Buildability submissions.

1.7.2 New minimum Buildable Design Scores for large commercial, industrial, institutional, school and other projects with GFA ≥ 25,000m²

To accelerate DfMA adoption for large projects which have greater scope for DfMA application and economies of scale, the minimum Buildable Design Scores for superstructure works of large commercial, industrial, institutional, school and other projects have been raised. Details are provided in Section 5.3 of this Code.

1.7.3 Mandatory adoption of industry standard components for Residential Non-landed projects

As modularisation is a key approach to achieve higher productivity and optimise benefits of DfMA, the following industry standard components are required for residential non-landed projects:

(a) 65% Precast Household Shelters, of which 60% are of industry standard sizes

(b) 65% Prefabricated Bathroom Units, of which 60% are of industry standard sizes

1.7.4 Enhanced outcome-based solutions for all large development types (GFA ≥ 25,000m²) in lieu of meeting minimum Buildable Design Score and Constructability Score

The key changes are listed below:

(a) Revised deemed-acceptable solutions for large residential non-landed projects
(b) New deemed-acceptable solutions for large commercial, industrial, institutional, school and other projects
(c) Revised minimum productivity improvement requirement under the ‘open’ option from 20% to 25% (from 2010’s level)

Details of the outcome-based solutions are provided in Annex C: Requirements for Outcome-based Solutions.

2 HOW TO USE THE BUILDABLE DESIGN APPRAISAL SYSTEM (BDAS)

2.1 Components of the Appraisal System

The BDAS provides a method to compute the Buildable Design Score of a design. It consists of five main parts:

(a) Pre-requisites;

(b) Structural System;

(c) Architectural System;

(d) Mechanical, Electrical and Plumbing (MEP) System; and

(e) Innovation and others.

The maximum points achievable for each of the five parts is as shown in Table 1. Different points are allocated to each discipline of Structural, Architectural and MEP works of different category of building works, based on manpower usage.

Table 1 Maximum Points for Structural System, Architectural System, MEP System and Innovation and Others for Each Category of Building Works

Category of Building Work / Development	Point weightages (Maximum Total Buildable Design Score: 120 points)				
		Structural S_N	Architectural A_N	MEP M_N	Innovation and others
Public Residential (non-landed)	Pre-requisites with no points given	S_1 45 points	A_1 40 points	M_1 15 points	20 points
Private Residential (non-landed)		S_2 35 points	A_2 45 points	M_2 20 points	
Commercial		S_3 35 points	A_3 30 points	M_3 35 points	
Industrial		S_4 50 points	A_4 25 points	M_4 25 points	
Institutional, School and others		S_5 35 points	A_5 30 points	M_5 35 points	
MRT Station		S_6 50 points	A_6 25 points	M_6 25 points	

2.1.1 Pre-requisites

Pre-requisites are mandatory items such as the use of welded floor mesh for cast in-situ concrete floors for all types of development and drywall for all internal dry areas of residential non-landed developments. Such pre-requisite items would not be given any points. Designers are to ensure that all pre-requisites, where applicable, are complied with when making submissions to BCA and adopted in projects.

The pre-requisite items are shown in Table 2.

Table 2 Pre-requisites

S/N	DESCRIPTION	UNIT OF COVERAGE	MINIMUM COVERAGE
For all projects			
1	Floor mesh[1]	Area	At least 65%
2	Repetition of typical floor height in multiples of 1.5M or 1.75M[2]	No.	At least 80%
3	Industry standard precast staircase for typical storeys[3][8]	No.	At least 80%
4	Prefabricated and pre-insulated duct for air-conditioning system[4]	Length	At least 65%
For all Residential Non-Landed projects			
5	Drywall[5]	Length	All internal dry areas excluding party wall / toilet wall / kitchen wall
6a	Precast household shelters (HS)[6][8]	No.	At least 65%
6b	Industry standard precast household shelters[6][8] *(see Table 2A)*	No.	At least 60%
7a	Prefabricated Bathroom Unit (PBU)[7][8]	No.	At least 65%
7b	Industry standard Prefabricated Bathroom Unit[7][8] *(see Table 2B)*	No.	At least 60%
8	Industry standard door structural openings (width) (3 most common sizes)[8] *(see Table 2C)*	No.	At least 65%
9	Industry standard precast refuse chutes[8] *(see Table 2D)*	No.	At least 80%

NOTE:

(1) The use of welded mesh is mandated for all types of development where cast in-situ slab has been adopted in the design. The minimum usage of welded mesh must be at least 65% of all cast in-situ slab area. The use of welded mesh must be indicated on plans.

(2) The typical floor-to-floor height must be in modules of 1.5M or 1.75M where 1.5M = 150 mm and 1.75M = 175mm.

(3) Precast staircases shall be with riser heights of either 150mm or 175mm and tread width of 275mm or 300mm for all projects except industrial projects. For industrial projects, precast staircases shall be with tread width of 250mm, 275mm or 300mm.

(4) For MRT stations, ducts serving dual functions of Supply Air Duct (SAD) and Smoke Extraction Duct (SED), and large ducts (with either width or depth exceeding 1,000mm), are allowed to be assembled and insulated on-site before installation.

(5) The drywall must be used for all internal dry areas such as between bedrooms, bedroom with living room etc.

(6) For designs of residential non-landed projects that incorporate household shelters, it is mandatory for these household shelters to be precast, and of which 60% shall be of the industry standard sizes as shown in Table 2A – Industry Standard Precast Household Shelters.

(7) For designs of residential non-landed projects, it is mandatory to adopt 65% prefabricated bathroom units, of which 60% shall be of the industry standard sizes as shown in Table 2B – Industry Standard Prefabricated Bathroom Units.

(8) Percentage of coverage is based on total number of components such as staircase flights, household shelters, bathroom units, door openings, refuse chutes etc.

EXPLANATORY NOTES TO TABLE 2

(a) A drywall partition consists of prefabricated boards typically made of gypsum (or other materials such as calcium silicate or fibre-based cement) that are screw-fastened to both sides of a metal stud framing system. No wet trades are involved. The type and number of layers of the boards, and the insulation material within the space formed by the metal framing system are determined by the desired strength, acoustic, fire and other performance criteria required of the partition.

For the mandatory use of drywall in all residential non-landed projects, the drywall must be used as partition wall for all internal dry areas such as between bedrooms, bedroom with living room etc., with the exception of party wall, toilet wall and kitchen wall (refer to Figure 1 below for illustration). The drywall used must achieve a performance grading of Severe Duty for strength and robustness.

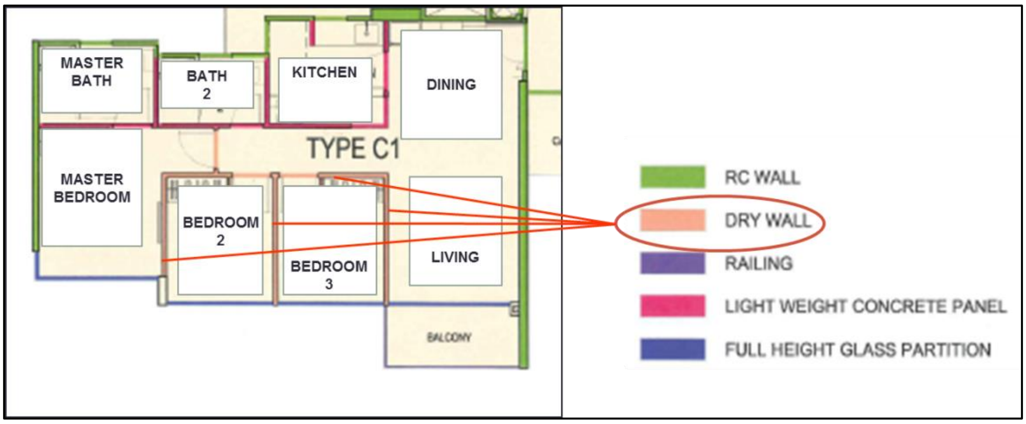


Figure 1 – Example of a layout showing the mandatory use of drywall for all internal dry areas.

(b) For residential non-landed projects that incorporate household shelters, it is mandatory to adopt a minimum of 65% precast household shelters, out of which at least 60% shall be of the industry standard sizes as shown in Table 2A. Points will be awarded only if a project adopts a minimum 80% industry standard precast household shelters.

Table 2A: Industry Standard Precast Household Shelters

GFA of Dwelling Unit (m^2)	Minimum Inner Floor Area (m^2)	Internal Dimension (without finishes) (m/m)	Wall Thickness (mm)
GFA ≤ 40	1.44	1.2 x 1.2	250 or 300
45 < GFA ≤ 75	2.2	1.2 x 1.9, 1.3 x 1.7, 1.3 x 1.75, 1.45 x 1.6	250 or 300
75 < GFA ≤ 140	2.8	1.2 x 2.35, 1.2 x 2.4, 1.25 x 2.3, 1.25 x 2.35, 1.3 x 2.2, 1.35 x 2.1, 1.45 x 1.95, 1.65 x 1.7	250 or 300
GFA > 140	3.4	1.5 x 2.4, 1.55 x 2.2, 1.55 x 2.5, 1.6 x 2.2	250 or 300

NOTE:

1. Precast household shelter design shall incorporate at least one hollow core in each of the four household shelter walls, except for 1.2m internal dimension household shelter wall where blast door is located. Design shall comply with prevailing Technical Requirements for Household Shelters.

(c) All residential non-landed projects are required to adopt a minimum of 65% Prefabricated Bathroom Units (PBU), of which 60% shall be of the industry standard sizes as shown in Table 2B. The PBU system has to be granted In-Principle Acceptance (IPA) by the Building Innovation Panel (BIP) and the fabrication facilities have been accredited under the Prefabricated Bathroom Unit Manufacturer Accreditation Scheme (PBU MAS). The requirements for PBU systems to be accepted are spelt out in Section 3. Please refer to BCA website for the list of accepted PBU systems. Points will be awarded only if a project adopts a minimum of 80% industry standard PBUs.

Table 2B: Industry Standard Prefabricated Bathroom Units

Internal Dimensions (without finishes) (m/m)		
Master Bath	**Common Bath**	**Maid / Yard Bath**
1.85 x 2.25	1.5 x 2.5	0.8 x 1.5
1.85 x 2.6	1.55 x 2.6	0.85 x 1.3
1.85 x 2.7	1.6 x 2.6	1.2 x 1.5
1.85 x 2.8	1.6 x 2.7	1.2 x 1.6
2.0 x 2.4	1.6 x 2.8	
2.0 x 2.6	1.75 x 1.85	
	1.75 x 2.05	
	1.75 x 2.25	
	1.8 x 2.6	
	1.8 x 2.8	

NOTE:

1. The sizes are based on internal dimensions, i.e. exclude the wall thickness and finishes of the prefabricated bathroom unit as shown in Figure 2 below.

2. Sizes for master bath can also be used for common bath and vice versa.

3. The location of the services shaft shall be accessible to facilitate future repair and maintenance work of the prefabricated bathroom units. Figure 3 below gives an example of a layout of a prefabricated bathroom unit with a services shaft that is accessible.

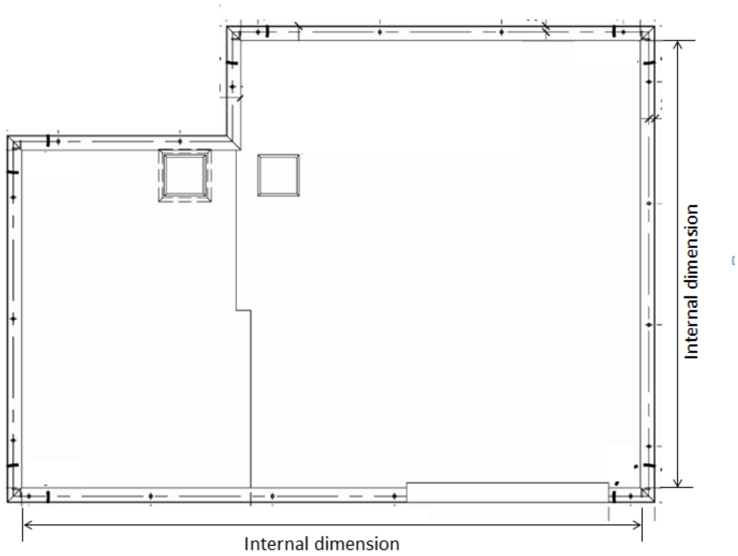


Figure 2 – Plan of a prefabricated bathroom unit and its internal dimensions

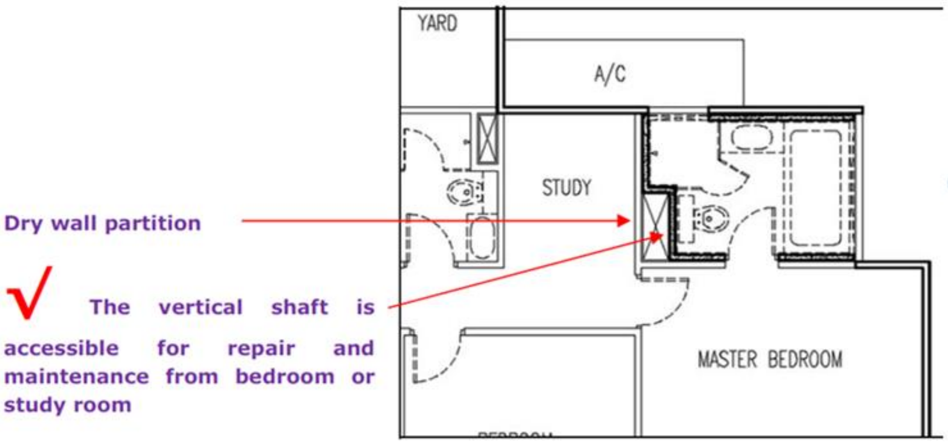


Figure 3 – Example of a layout of a prefabricated bathroom unit with a services shaft that is accessible for future repairs and maintenance

(d) It is mandatory for all residential non-landed projects to adopt the standard door structural opening sizes (up to 3 sizes) as shown in Table 2C.

Table 2C: Industry Standard Door Structural Openings

S/N	Door Structural Opening (Width) (mm)
1	900
2	1000
3	1100
4	1200
5	1250
6	1500
7	2000

NOTE:

1. For other types of projects, points are awarded to a project if the above standard door structural opening sizes (up to 3 sizes) are adopted and meeting the required percentage of coverage as shown in Table 4 – Architectural Systems, Finishes and Buildable Features.

(e) It is a mandatory for all residential non-landed projects to adopt one of the standard precast refuse chute sizes as shown in Table 2D. For precast refuse dual chutes, any of the inner dimensions as shown can be adopted with wall thickness of 100mm, 150mm or 200mm.

Table 2D: Industry Standard Precast Refuse Chutes

S/N	Outer Dimensions (m)	Inner Dimensions (m)	Chamfer Radius (mm)
1	1.0 x 1.0	0.8 x 0.8 or 0.8 diameter	150
2	0.9 x 0.9	0.7 x 0.7 or 0.7 diameter	N.A.
3	0.9 x 0.9 or 0.9 x 1.2	0.65 x 0.65 or 0.65 diameter	N.A.
4	0.8 x 0.8 or 0.8 x 1.1	0.6 x 0.6 or 0.6 diameter	N.A.

2.1.2 Buildable Design Score of Structural System

A designer could adopt different DfMA technologies and structural systems for different parts of the building so as to achieve the best practical design. The DfMA technologies are grouped into Prefabricated Components, Advanced Prefabricated Systems, Fully Integrated Sub-assemblies and Fully Integrated Systems according to the potential manpower savings expected from their adoption.

The Buildable Design Score for a particular DfMA technology or structural system is the product of the percentage area covered by the DfMA technology or structural system and its corresponding allocated points as shown in Table 3.

In this Part, points are also given for the use of various structural buildable design features such as prefabricated reinforcement cages for beams, columns and walls, large panel slabs, integrated precast components, mechanical connections, precast slab with lattice girder reinforcement and high strength concrete. Other items that are recognised with points include use of modular dimensions for columns and beams and vertical repetition of structural floor layout. The Buildable Design Score for each buildable design feature is the product of the percentage of coverage of use and the corresponding allocated points as shown in Table 3.

Table 3 **Structural Systems and Buildable Features – S_N Value**

S/N	DESCRIPTION	ALLOCATED POINTS, S_N			
		S_1	S_2	S_3, S_5	S_4, S_6
DfMA Structural Systems					
1. Fully Integrated Systems					
1.1	Prefabricated Prefinished Volumetric Construction (PPVC)	45	35	35	50
2. Fully Integrated Sub-assemblies					
2.1	Mass Engineered Timber (MET)(1) / Hybrid system of MET with structural steel(2) or precast concrete(2)	42	33	34	48
3. Advanced Prefabricated Systems					
3.1	Structural steel(2) / Hybrid system of structural steel(2) and precast concrete	39	32	33	46
3.2	Advanced Precast Concrete System (APCS) comprising precast slab with at least 4 of the features listed below (each with at least 65% coverage):	39	32	33	46
3.2 (a)	Integrated precast components (comprising at least 2 structural / architectural elements) e.g. double bay façade wall, beam-façade wall, multi-tier column/wall(3), precast household shelter, precast refuse chute, prefabricated bathroom unit, prefinished façade wall, precast external wall with cast-in windows	*Denominator:* *All columns / walls / façade walls / household shelters / refuse chutes / bathrooms (in No. <u>or</u> Length for walls)*			
3.2 (b)	Mechanical connection for precast column / precast wall(3) (horizontal joints) e.g. column shoes, grouted sleeves, spiral connectors	*Denominator:* *All columns / walls(3) (in No. <u>or</u> Length for walls)*			
3.2 (c)	Mechanical connection for precast beam (e.g. telescopic beam connector, grouted sleeves) / Integrated prefabricated column and beam junction (e.g. Lotus-Root system, slim floor system e.g. Deltabeam)	*Denominator:* *All beams (in No.)*			
3.2 (d)	Mechanical connection for precast wall (vertical joints) e.g. flexible loops	*Denominator:* *All façade and parapet walls (Length)*			
3.2 (e)	Mechanical connection for other precast components e.g. mechanical connections for parapet walls, staircases *(For staircase, the staircase flight and landing slabs shall be in precast concrete)*	*Denominator:* *All parapet walls / staircases (in No. <u>or</u> Length for walls)*			

S/N	DESCRIPTION	ALLOCATED POINTS, S_N			
		S_1	S_2	S_3, S_5	S_4, S_6
3.2 (f)	Large precast panel slab (e.g. hollow core slab / double T slab / precast planks) ≥ 2.4m width	*Denominator:* *Total precast slab area (in m^2)*			
4. Prefabricated Components					
4.1	Prefabricated slab and column/wall[3] <u>or</u> Prefabricated slab and beam	35	29	32	41
4.2	Prefabricated column/wall[3] and beam	35	29	32	41
4.3	Prefabricated column/wall[3] only	28	23	26	34
4.4	Prefabricated slab only	28	23	26	34
Other Structural Systems					
5. Cast In-situ Systems					
5.1	Flat plate / flat slab	22	20	24	28
5.2	Beam-slab system	10	10	11	15
6. Other System(s) Not Listed Above					
6.1	*Description of structural system(s)*	*Points for other structural systems not shown in this Table shall be determined by BCA on a case-by-case basis. For such cases, the QPs are advised to seek BCA's comments before proceeding with the designs.*			

NOTE:

(1) The area of coverage for MET is based on the total floor area including roof. A building is deemed to be constructed using engineered timber if both the floor (including roof) and wall are constructed using engineered timber.

(2) At least 80% of the steel reinforcement for composite slab must be welded mesh.

(3) Precast wall refers to load-bearing walls only.

Table 3 Structural Systems and Buildable Features – S_N Value (continued)

S/N	DESCRIPTION	UNIT OF COVERAGE	ALLOCATED POINTS, S_N	
			PERCENTAGE OF COVERAGE(4)	
			≥ 65% to < 80%	≥ 80%
7. Simplicity				
7.1 (a)	Prefabricated reinforcement cage for beam	No.	3.0	4.0
7.1 (b)	Prefabricated reinforcement cage for column	No.	3.0	4.0
7.1 (c)	Prefabricated reinforcement cage for wall	No.	3.0	4.0
7.2	Large precast panel slab / Integrated precast components (2 elements) e.g. double bay façade wall, beam-façade wall, multi-tier column/wall ***(only if points are not claimed under Item 3.2)***	No.	2.0	2.5
7.3 Mechanical Connections ***(only if points are not claimed under Item 3.2)***				
7.3 (a)	For precast column / precast wall (horizontal joints) e.g. column shoes, grouted sleeves, spiral connectors	No. or Length for walls	1.0	1.5
7.3 (b)	For precast beam (e.g. telescopic beam connector, grouted sleeves) / Integrated prefabricated column and beam junction (e.g. Lotus-Root system, slim floor system e.g. Deltabeam)	No.	1.0	1.5
7.3 (c)	For precast wall (vertical joints) e.g. flexible loops	Length	1.0	1.5
7.3 (d)	For other precast components e.g. mechanical connections for parapet walls, staircases *(For staircase, the staircase flight and landing slabs shall be in precast concrete)*	No. or Length for walls	1.0	1.5
7.4	Precast slab with lattice girder reinforcement	Area	1.0	1.5
7.5	High strength concrete (at least Grade C60/75)(5) *(minimum adoption is 5% of total concrete volume)*	Volume	2.0	

S/N	DESCRIPTION	UNIT OF COVERAGE	ALLOCATED POINTS, S_N	
			PERCENTAGE OF COVERAGE(4)	
			≥ 65% to < 80%	≥ 80%
8. Modularisation				
8.1	Columns (3 most common sizes in module of 0.5M)(6)	No.	2.0	2.5
8.2	Beams (3 most common sizes in module of 0.5M)(6)	No.	2.0	2.5
8.3	Precast columns (in module of 0.5M) ***(only if points are not claimed under Item 8.1)***	Nos.	2.0	2.5
8.4	Vertical repetition of structural floor layout(7)	Area	2.0	2.5
9. Industry Standardisation				
9.1	Industry standard precast household shelters(8) *(see Table 2A)*	No.	-	2.5
9.2	Industry standard precast beams *(see Table 3A)*	Nos.	2.0	2.5
10. Other Buildable Feature(s) Not Listed Above				
10.1	*Description of buildable feature(s)*	*Points for other buildable features not shown in this Table shall be determined by BCA on a case-by-case basis. For such cases, the QPs are advised to seek BCA's comments before proceeding with the designs.*		

NOTE:

(4) Percentage of coverage is to be based on total number of components, total floor area, or total volume of concrete.

(5) High strength concrete of at least C60/75 must be used for at least 5% of the total concrete volume.

(6) The module of 0.5M does not apply to steel columns and beams.

(7) The repetition may omit bottom floor, top floor and above. Only applicable if there are at least 2 floors remaining after the floor omission.

(8) As adoption of industry standard precast household shelters is a pre-requisite for residential non-landed projects, points are awarded only if a project adopts a minimum of 80% industry standard sizes as shown in Table 2A – Industry Standard Precast Household Shelters.

EXPLANATORY NOTES TO TABLE 3

(a) Table 3 has been arranged into DfMA structural systems namely Fully Integrated Systems, Integrated Sub-assemblies, Advanced Prefabricated Systems and Prefabricated Components, as well as other systems according to the potential manpower savings expected from their adoption. In the event when a structural system used for a project is not stated in Table 3, the points allocated shall be decided by BCA.

(b) For prefabricated components, points are given according to the combinations of precast components (slab, column/wall and beam) used.

(c) Flat plate refers to a slab design which does not have column heads or drop panels. Under BDAS, a flat plate system could be viewed as a floor with flat soffit (with the exception of perimeter beams). From the buildability point of view, such floor with flat soffit would ease formwork construction and reinforcement work at site considerably and helps to improve site productivity.

(d) For designs that adopt an integrated metal roof which is a prefabricated roofing system complete with insulation and can be installed as an entire roof section, such a roof system can be considered as a structural steel system.

(e) The percentage of coverage for the use of prefabricated reinforcement/cages is to be based on the total number of cast in-situ beams or total number of cast in-situ columns or total number of cast in-situ walls. The use of prefabricated reinforcement/cages must be indicated on plans.

(f) For modular dimensions of columns and beams, the module requirement must be met before points are given. 1M denotes 100mm. 0.5M implies that sizes must be in multiples of 50mm.

(g) Residential non-landed projects that adopt industry standard precast beam sizes as shown in Table 3A below will be accorded points.

Table 3A: Industry Standard Precast Beam Sizes for Residential Non-landed Projects

S/N	Precast beam sizes (mm)
1	200 x 400
2	200 x 450
3	250 x 500
4	250 x 550
5	300 x 550
6	300 x 600

2.1.3 Buildable Design Score of Architectural System

Designs are appraised on the DfMA technologies, architectural wall systems and architectural finishes adopted. The DfMA technologies are grouped into Prefabricated Components, Advanced Prefabricated Systems, Fully Integrated Sub-assemblies and Fully Integrated Systems according to the potential manpower savings expected from their adoption.

The Buildable Design Score for a particular DfMA technology or wall system is computed by multiplying the percentage of wall length covered by the DfMA technology or wall system and its corresponding allocated points as shown in Table 4. For finishes, the Buildable Design Score is computed by multiplying the percentage of wall length, the area of floor or the area of ceiling covered by the type of finishes and its corresponding allocated points as shown in Table 4.

In addition, to balance aesthetics and buildability of complex designs such as buildings designed with high voids or are tilted, twisted or with complex forms, up to 5 direct points are awarded to encourage designs that are simple to construct.

In this Part, points are also given for the use of various architectural buildable design features, modular dimensions, repetition and standardisation of components/design. Examples include horizontal grids and PPVC modules in modular dimensions, horizontal design repetition of unit layouts, repetition of PPVC modules and PBUs, standard door structural openings etc. The Buildable Design Score is the product of the percentage of coverage of use and the corresponding allocated points as shown in Table 4.

Table 4 Architectural Systems, Finishes and Buildable Features – A_N Value

S/N	DESCRIPTION	ALLOCATED POINTS, A_N			
		A_1	A_2	A_3, A_5	A_4, A_6
DfMA Architectural Wall Systems					
1. Fully Integrated Systems					
1.1	Prefabricated Prefinished Volumetric Construction (PPVC)(1)	30	30	20	20
2. Fully Integrated Sub-assemblies					
2.1	Prefabricated and prefinished wall with Mechanical, Electrical and Plumbing (MEP) services	28	29	18	19
2.2	Prefabricated Bathroom Unit (PBU)(2)	28	29	18	19
3. Advanced Prefabricated Systems					
3.1	Prefabricated and prefinished wall / Precast wall off-form(3)	27	27	17	18
4. Prefabricated Components					
4.1 (a)	Drywall partition for party wall / wet areas (For residential non-landed projects)	25	26	16	17
4.1 (b)	Drywall partition for other areas(4)	25	26	16	17
4.2	Curtain wall / Full height glass partition / Prefabricated railing	25	26	16	17
4.3	Precast concrete wall(5)	25	26	16	17
4.4	Lightweight concrete panel(6)	22	22	13	13
5. Other Wall Systems					
5.1	Cast in-situ wall	16	16	10	12
5.2	Precision blockwall	5	5	5	4
5.3	Brickwall / blockwall	0	0	0	0
6. Other System(s) Not Listed Above					
6.1	*Description of wall system(s)*	*Points for other wall systems not shown in this Table shall be determined by BCA on a case-by-case basis. For such cases, the QPs are advised to seek BCA's comments before proceeding with the designs.*			

NOTE:

(1) Please refer to Section 4 for the requirements and acceptance framework for PPVC.

(2) Please refer to Section 3 for the requirements and acceptance framework for PBU.

(3) Off-form cast in-situ concrete and off-form precast concrete external walls and columns do not require additional labour-intensive surface treatment.

(4) The use of drywall in all internal dry areas of residential non-landed projects is mandatory. No points would be given in this case as stated under Part 2.1.1.

(5) Precast concrete walls refer to precast walls that are generally non-proprietary and manufactured to customise to a specific project.

(6) Lightweight concrete panels include autoclaved lightweight concrete (ALC) panels, autoclaved aerated concrete (AAC) panels.

Table 4 Architectural Systems, Finishes and Buildable Features – A_N Value (continued)

S/N	DESCRIPTION	ALLOCATED POINTS, A_N [7]			
		A_1	A_2	A_3, A_5	A_4, A_6
DfMA Architectural Finishes					
7. Fully Integrated Systems					
7.1	Prefabricated Prefinished Volumetric Construction (PPVC)[1]	10	15	5	10
8. Fully Integrated Sub-assemblies					
8.1	Prefabricated and prefinished wall / floor / ceiling with MEP services	8	12	4	9
8.2	Prefabricated Bathroom Unit (PBU)[2]	8	12	4	9
9. Advanced Prefabricated Systems					
9.1	Prefabricated and prefinished wall / floor / ceiling, curtain wall, glass wall partition	6	9	3	7
10. Productive Finishes					
10.1	Drywall partition, prefinished ceiling	4	7	3	5
10.2	Power float concrete floor, vinyl flooring, prefinished timber flooring, carpet, raised floor, engineered stone flooring finishes, and wallpaper	4	7	3	5
11. Other Finishes					
11.1	Large format tiles	2	4	2	4
11.2	Skim coat, vinyl tiles for wall	0	0	0	0
11.3	Plastering and other finishes e.g. tiles	0	0	0	0
11.4	*Description of other finishes not listed above*	*Points for other finishes not shown in this Table shall be determined by BCA on a case-by-case basis. For such cases, the QPs are advised to seek BCA's comments before proceeding with the designs.*			

NOTE:

(7) Points are not applicable to wall, floor and ceiling with no finishes.

Table 4 Architectural Systems, Finishes and Buildable Features – A_N Value (continued)

S/N	DESCRIPTION	UNIT OF COVERAGE	ALLOCATED POINTS, A_N	
			PERCENTAGE OF COVERAGE[8]	
			≥ 65% to < 80%	≥ 80%
12. Simplicity				
12.1	Design without high voids	See Table 4A		
12.2	Design without complex form	See Table 4B		
13. Modularisation				
13.1	Horizontal grids in module of 3M[9]	No.	2.0	3.0
13.2	Dimension of PPVC modules in module of 0.5M[1][10]	No.	2.0	3.0
13.3	Precast façade/wall with length in module of 3M	No.	2.0	3.0
13.4	Precast service ducts with width in module of 1.5M	No.	2.0	3.0
13.5	Windows (3 most common sizes in modules of 1M)[11]	No.	2.0	2.5
13.6	Horizontal design repetition of unit layouts[12]	30 to 34 Repetitions	2.50	
		Repetition ≥ 35	3.00	
13.7	Repetition of PPVC modules[1][13]	≥ 80 Repetitions	4.00	
		70 to 79 Repetitions	3.00	
		60 to 69 Repetitions	2.00	
		50 to 59 Repetitions	1.00	
13.8	Repetition of PBUs[2]	≥ 40 Repetitions	3.5	4.0
		< 40 Repetitions	2.5	3.0

NOTE:

(8) Percentage of coverage is applicable to Items 13.1, 13.2, 13.3, 13.4, 13.5, 14.1, 14.2, 14.3, 14.4, 15.1 and 15.2 based on total number of components.

(9) Horizontal grids in both vertical and horizontal axis shall be in multiples of 3M (300mm).

(10) Dimension of PPVC modules in multiples of 0.5M (50mm) refers to external PPVC module dimensions on plan in both length and width, including gaps.

(11) Sizes are based on dimensions of frames. 1M for width and 1M for height (1M = 100 mm).

(12) Horizontal design repetition of unit layouts is to be computed at project level. Mirrored unit layouts are considered as unique layouts.

(13) Repetition of PPVC modules is to be computed at project level. Mirrored PPVC modules are considered as unique modules.

Table 4 **Architectural Systems, Finishes and Buildable Features – A_N Value (continued)**

S/N	DESCRIPTION	UNIT OF COVERAGE	ALLOCATED POINTS, A_N	
			PERCENTAGE OF COVERAGE[8]	
			≥ 65% to < 80%	≥ 80%
14. Industry Standardisation				
14.1	Industry standard door structural openings (width) (3 most common sizes)[14] *(see Table 2C)* ***(for all projects excluding Residential Non-landed)***	No.	2.0	2.5
14.2	Industry standard prefabricated bathroom / toilet units[15] *(see Table 2B)*	No.	-	2.5
14.3	Industry standard PPVC module for bedrooms (internal width)[16] ***(for residential non-landed projects only)*** *(see Table 4C)*	No.	2.0	3.0
14.4	Industry standard windows (width)[17] ***(for residential non-landed projects only)*** *(see Table 4D)*	No.	2.0	2.5
15. Others				
15.1	Prefabricated Kitchen Unit (PKU) accepted by Building Innovation Panel (BIP)	No.	2.5	4.0
15.2	Pole system wardrobe / Modular kitchen cabinets	No.	2.5	4.0
16. Other Buildable Feature(s) Not Listed Above				
16.1	*Description of buildable feature(s)*	*Points for other buildable features not shown in this Table shall be determined by BCA on a case-by-case basis. For such cases, the QPs are advised to seek BCA's comments before proceeding with the designs.*		

Table 4 Architectural Systems, Finishes and Buildable Features – A_N Value (continued)

S/N	DESCRIPTION	UNIT OF COVERAGE	ALLOCATED POINTS, A_N	
			PERCENTAGE OF COVERAGE	
			< 30%	≥ 30%
17. Demerit Points				
17.1	Cast in-situ floor with transfer beam / cantilever transfer beam[18]	No.	-1.0	-2.0
17.2	Inclined columns[19]	No.	-1.0	-1.5
17.3	Non-functional void on slab[20]	No.	-1.0	

NOTE:

[14] The use of standard door structural openings in all residential non-landed projects is mandatory. No points would be given in this case as stated under Part 2.1.1. For other types of project, points are awarded only if the sizes of standard door structural openings (up to 3 sizes) shown in Table 2C – Industry Standard Door Structural Openings are adopted.

[15] Points are awarded if a project adopts a minimum of 80% industry standard PBUs as shown in Table 2C – Industry Standard Prefabricated Bathroom Units.

[16] Points are awarded to a residential non-landed project only if the sizes of PPVC modules (internal width without finishes) shown in Table 4C – Industry Standard PPVC Modules for Bedrooms of Residential Non-landed Projects are adopted.

[17] Points are awarded to a residential non-landed project only if the sizes of windows (width) shown in Table 4D – Industry Standard Windows for Residential Non-landed Projects are adopted.

[18] For cast in-situ floor with cast in-situ transfer beam/cantilever transfer beam, the number of points to be deducted depends on the percentage of coverage of columns that are transferred. This requirement does not apply to cast in-situ floor with transfer beam designed for ramp access or designed to support PPVC modules.

[19] The number of points to be deducted depends on the percentage of coverage of columns that are inclined on that floor. Point deduction applies to blocks with inclined columns according to the percentage of coverage.

[20] This refers to void on slab that does not serve any functional requirement and is enclosed by walls. The 1.0 point deduction applies even if there is only one such void within a block.

EXPLANATORY NOTES TO TABLE 4

(a) Table 4 has been arranged into DfMA architectural wall systems namely Fully Integrated Systems, Integrated Sub-assemblies, Advanced Prefabricated Systems and Prefabricated Components, as well as other wall systems and architectural finishes according to the potential manpower savings expected from their adoption. In the event when a wall system used for a project is not stated in Table 4, the points allocated shall be decided by BCA.

(b) Precision blocks refer to lightweight concrete blocks that have precise dimensions (± 1mm dimensional tolerance) and can be laid on thin bed adhesive mortar.

(c) For designs that have high voids, the percentage of the high void is calculated by dividing the sum of all heights greater than 9m by the total building height. Depending on the percentage computed, direct points are given accordingly as shown in Table 4A.

Table 4A: Points for designs without high voids

Case	Percentage of high void[(1)(2)] = Total void height (only for heights > 9m) / Total building height (m)	Points
1	0% (no high voids)	2.00
2	0% < % of high void < 10%	1.50
3	10% ≤ % of high void < 15%	1.00
4	15% ≤ % of high void < 20%	0.50
5	% of high void ≥ 20%	0.00

NOTE:

(1) High voids refer to heights that are more than 9m.

(2) A design that does not have any void height greater than 9m throughout its building height will get a maximum of 2 points.

(d) The following considerations are taken into account for designs with complex form:

- maximum offset of the building's superstructure floor plates measured against that of the ground floor plate;
- percentage of total number of floors with offsets measured against the total number of floors of the building; and
- overall height of the building

Depending on the building height, points are awarded based on the lower of the points given for maximum offset and percentage of offset floors as shown in Table 4B.

Table 4B: Points for designs without complex form[1][2]

Scenario	1	2	3	4	5	6
Maximum Offset	Nil	0m to < 1m	1m to < 2m	2m to < 3m	3m to < 4m	≥ 4m
% of Offset Floors / **Height of building**	Nil	< 5%	5% to < 15%	15% to < 25%	25% to < 35%	≥ 35%
0 m < 15 m	3.00	3.00	3.00	2.50	1.50	0.00
15 m < 45 m	3.00	3.00	2.50	1.50	1.00	0.00
45 m < 90 m	3.00	2.50	1.50	1.00	0.00	0.00
90 m < 135 m	3.00	1.50	1.00	0.00	0.00	0.00
≥ 135 m	3.00	1.00	0.00	0.00	0.00	0.00

NOTE:

(1) Complex forms refer to building façades that are tilted, tapered, twisted or of free form.

(2) A design that does not have complex form will get a maximum of 3 points.

(e) For the Part on Architectural Buildable Features, the module requirement (where applicable) must be met before points are given. 0.5M implies that sizes must be in multiples of 50mm. 1M implies that sizes must be in multiples of 100mm. For repetition of horizontal grids, 3M implies that spacing between grids must be in multiples of 300mm. For PPVC module dimensions, 0.5M implies that the dimension of PPVC modules on plan (both length and width) must be in multiples of 50mm. For precast façade/wall, 3M implies that the length must be in multiples of 300mm. For precast service ducts, 1.5M implies that the width must be in multiples of 150mm. For windows, 1M implies that both the width and height of the window frames must be in multiples of 100mm.

(f) Accepted Prefabricated Bathroom Unit (PBU) systems refer to those that have been granted In-Principle Acceptance (IPA) by the Building Innovation Panel (BIP), and the fabrication facilities have been accredited under the PBU Manufacturer Accreditation Scheme (PBU MAS). The requirements and acceptance framework for PBU systems are spelt out in Section 3.

(g) Repetition of layouts for PBUs is computed based on (Total number of PBUs)/(Total number of PBU sizes). PBU sizes are based on their internal dimensions without finishes. Mirror images of PBUs are treated as unique size.

(h) For industry standardisation of precast household shelters, PBUs and door structural openings, please refer to Table 2A, Table 2B and Table 2C respectively for the sizes.

(i) Industry standard PPVC module sizes for bedroom (internal width) for residential non-landed projects are as shown in Table 4C.

Table 4C: Industry Standard PPVC Module Sizes for Bedrooms of Residential Non-landed Projects

S/No	PPVC modules for bedroom (mm) (internal width without finishes)
1	2600
2	2700
3	2800
4	2900
5	3000

(j) Industry standard window sizes (width) for residential non-landed projects are as shown in Table 4D.

Table 4D: Industry Standard Window Sizes (Width) for Residential Non-landed Projects

S/No	Window (width) (mm)
1	600
2	750
3	800
4	850
5	900
6	1200
7	1500
8	1800
9	2400

2.1.4 Buildable Design Score of Mechanical, Electrical and Plumbing (MEP) System

Designers have the flexibility to adopt a range of DfMA MEP technologies, systems and components. The DfMA technologies are grouped into Prefabricated Components, Advanced Prefabricated Systems, Fully Integrated Sub-assemblies and Fully Integrated Systems according to the potential manpower savings expected from their adoption. Examples include prefabricated MEP vertical modules, horizontal modules and plant modules which can also be integrated with structural or architectural systems to achieve higher productivity, as well as individual components such as flexible sprinkler droppers, flexible water pipes, common M&E brackets and pre-insulated mechanical pipings.

The Buildable Design Score for a particular DfMA MEP technology or system is generally computed by multiplying the percentage area covered by the DfMA or prefabricated MEP system and its corresponding allocated points as shown in Table 5. Buildable design features such as mechanical connections for MEP components and industry standard sizes for prefabricated pump skids are also given points.

For advanced prefabricated systems, the criteria for qualifying area is as shown in Table 5A.

Table 5 Mechanical, Electrical and Plumbing (MEP) Systems and Buildable Features – M_N Value

S/N	DESCRIPTION	ALLOCATED POINTS, M_N [(2)]			
		M_1	M_2	M_3, M_5	M_4, M_6
DfMA MEP Systems					
1. Fully Integrated Systems					
1.1	Prefabricated Prefinished Volumetric Construction (PPVC)[(1)]	15	20	25	35
2. Fully Integrated Sub-assemblies					
2.1	Prefabricated MEP modules integrated with structural or architectural system	12	16	20	28
3. Advanced Prefabricated Systems					
3.1	Prefabricated MEP vertical modules	4	6	7	11
3.2	Prefabricated MEP horizontal modules	4	6	7	11
3.3	Prefabricated MEP plant modules	4	6	7	11

NOTE:

(1) Please refer to Section 4 for the requirements and acceptance framework for PPVC.

(2) Percentage of coverage is based on area. Refer to Table 5A for criteria in determining qualifying area.

S/N	DESCRIPTION	UNIT OF COVERAGE	ALLOCATED POINTS, M_N			
			PERCENTAGE OF COVERAGE ≥ 80%[(3)]			
			M_1	M_2	M_3, M_5	M_4, M_6
DfMA MEP Components						
4. Prefabricated Components						
4.1	Flexible sprinkler droppers	No.	1.5	2.0	2.5	4.0
4.2	Flexible water pipes	No.	1.5	2.0	2.5	4.0
4.3	Common M&E bracket (at least 3 M&E services)	Length	1.5	2.0	2.5	4.0
4.4	Pre-insulated mechanical piping e.g. chilled water pipes	Length	1.5	2.0	2.5	4.0
5. Other System(s) Not Listed Above						
5.1	*Description of MEP system(s)*	*Points for other MEP systems not shown in this Table shall be determined by BCA on a case-by-case basis. For such cases, the QPs are advised to seek BCA's comments before proceeding with the designs.*				

NOTE:

(3) Percentage of coverage is based on total number of components or total length of bracket/piping.

Table 5 **Mechanical, Electrical and Plumbing (MEP) Systems and Buildable Features – M_N Value (Continued)**

S/N	DESCRIPTION	UNIT OF COVERAGE	ALLOCATED POINTS, M_N	
			PERCENTAGE OF COVERAGE(3)	
			≥ 65% to < 80%	≥ 80%
6. Industry Standardisation and Others				
6.1	Mechanical connection for MEP Components	Area	1.0	2.0
6.2	Industry standard sizes for prefabricated pump skids *(see Table 5B)*	No.	0.5	1.0

EXPLANATORY NOTES TO TABLE 5

(a) Table 5 has been arranged into DfMA MEP systems namely Fully Integrated Systems, Integrated Sub-assemblies, Advanced Prefabricated Systems and Prefabricated Components according to the potential manpower savings expected from their adoption. In the event when a MEP system used for a project is not stated in Table 5, the points allocated shall be decided by BCA.

(b) The criteria to determine the qualifying area for prefabricated MEP systems and the computation of percentage of coverage of adoption are as shown in Table 5A. These shall apply to all categories of building works.

Table 5A: Computation of Qualifying Area and Prefabricated Area of Prefabricated MEP Systems

S/No	Item	Criteria of Qualifying Area
1	**<u>Prefab MEP modules integrated with structural or architectural system</u>** *e.g. Working platform / catwalk / façade / wall / ceiling / slab, etc.*	To consult BCA
2	**<u>Vertical modules</u>** *e.g. Prefab water / gas risers, prefab hose reel risers* Coverage of Vertical modules (%) = Prefabricated Vertical Area (m^2) ÷ Qualifying Vertical Area (m^2) *where,* *Prefabricated Vertical Area (m^2) = Sum [Internal wall-to-wall width of Riser(s) x Total height of Riser(s) adopting prefabricated modules]* *Qualifying Vertical area (m^2) = Sum [Internal wall-to-wall width of Riser(s) x Total height of Riser(s)]*	**Risers or service ducts comprising the following services, where available:** a. Chilled water risers b. Plumbing and sanitary risers c. Firefighting services i.e. sprinkler, hose reel and dry/wet rising mains d. Electrical risers **Exclusions:** a. Risers within residential dwelling units b. Mechanical risers: • 1 no. pipe only; or • 2 no. pipes and any of them is ≤ 200mm in overall diameter c. Electrical risers with ≤ 2 no. components in cable containment system d. Extra Low Voltage (ELV) and High Tension (HT) risers

<table>
<tr><th>S/No</th><th>Item</th><th>Criteria of Qualifying Area</th></tr>
<tr><td>3</td><td><u>Horizontal modules</u>
e.g. Prefab ceiling modules

Coverage of Horizontal modules (%) = Prefabricated Horizontal Area (m^2) ÷ Qualifying Horizontal Area (m^2)

where,

Prefabricated Horizontal Area (m^2) = Sum [Corridor width x Total length of the Corridor adopting prefabricated modules]

Qualifying area (m^2) = Sum [Corridor width x Total length of the Corridor(s)]

Note:
(i) On-site works of up to 35% of the length of the corridor shall be allowed to account for junctions, bends and module connections, and this length could be considered for prefabricated horizontal area</td><td>All common corridor areas (including lift lobbies)

Exclusions:
a. Floors with non-typical layouts
b. Corridor with length totaling less than:
• 12m per floor for residential non-landed developments
• 30m per floor for all other developments
c. Corridors that only contain M&E fixtures/services that are directly mounted to the ceiling soffit</td></tr>
<tr><td>4</td><td><u>Plant modules</u>

Coverage of Plant modules (%) = Prefabricated Plant Area (m^2) ÷ Qualifying Plant Area (m^2)

where,

Prefabricated Plant Area (m^2) = Sum [Plan area of the Plant rooms or Skids of prefabricated M&E Equipment]

Qualifying area (m^2) = Sum [Plan Area of the Plant rooms or Skids in qualifying area]</td><td>M&E rooms/skids containing the following:

a. Potable water pumps
b. NEWater pumps
c. Sprinkler pumps
d. Hose reel pumps
e. Chilled water pumps
f. Condenser water pumps</td></tr>
</table>

S/No	Item	Criteria of Qualifying Area
	Note: (i) The area of plant room is considered if pump(s) are enclosed in the plant room. The area of skid is used if the pump(s) are not enclosed in a plant room. (ii) For a plant room where ≥ 65% of the equipment (by no.) is prefabricated, prefabricated plant area (m^2) can be considered as the total area of that particular plant room. (iii) For a plant room where < 65% of the equipment (by no.) is prefabricated, prefabricated plant area shall be computed based on the following: *Prefabricated plant area (m^2) = Plan area of the plant room (m^2) x No. of prefabricated equipment ÷ Total no. of equipment*	

NOTE:

Other proposed areas could be considered and included in the coverage of prefabricated MEP modules subject to productivity improvement on a case-by-case basis of coverage.

(c) Points are awarded to projects that adopt industry standard prefabricated pump skid sizes as shown in Table 5B.

Table 5B: Industry standard prefabricated pump skid sizes

S/N	Industry Standard Prefabricated Pump Skid Sizes
1	2.2 m x 1.5 m
2	2.2 m x 1.7 m
3	2.2 m x 2.2 m

2.1.5 Buildable Design Score of Innovations and Others

The total Buildable Design Score achievable for Innovation and others is 20 points across all categories of building works.

Points are awarded under this Part to recognise new and innovative technologies which can result in at least 20% manpower savings. Some examples include Prefabricated Kitchen Units (PKU), Prefabricated Common Toilets (PCT), prefabricated wavy façades, and innovative structural steel connections that do not require site welding and allow faster erection and easy on-site installation of steel members.

To encourage adoption of quality products, points are given to prefabricated components, PPVC modules, PBUs and MEP systems produced or fabricated in facilities which have obtained accreditation under the Precaster Accreditation Scheme (PAS) or respective Manufacturer Accreditation Scheme (MAS).

2.2 Computation of Buildable Design Score

The Buildable Design Score formula is expressed as:

Buildable Design Score (B-Score) of Superstructure or Basement	=	Buildable Design Score of Structural System (including Roof System) + Buildable Design Score of Architectural System + Buildable Design Score of MEP System + Buildable Design Score of Innovations and others
B-Score	=	$\{[\sum(A_s \times S_N)] + \text{Structural Buildable Features Points}\}^{\#}$ $+ \{[\sum(L_w \times A_N)] + [\sum(A_f \times A_N)] + C + \text{Architectural Buildable Features Points}\}^{@}$ $+ \{[\sum(A_m \times M_N)] + \text{MEP Buildable Features Points}\}^{\wedge}$ $+ I^{*}$
where,		
A_s	=	A_{sa} / A_{st}
A_s	=	Percentage of total floor area using a particular structural system
A_{sa}	=	Floor area using a particular structural system
A_{st}	=	Total floor area which includes roof (projected area) or Total basement area
S_N	=	Maximum allocated points for Structural System (Table 3)
Structural Buildable Features Points	=	Points for the use of buildable designs/features such as standard columns and beams, vertical repetition of layout, high strength concrete (Table 3)
L_w	=	L_{wa} / L_{wt}
L_w	=	Percentage of total wall length using a particular wall system
L_{wa}	=	Wall length using a particular wall system
L_{wt}	=	Total wall length, excluding the length of external basement wall for earth retaining purpose
A_N	=	Maximum allocated points for Architectural System (Table 4)
A_f	=	A_{fa} / A_{ft}
A_f	=	Percentage of total wall length and area of floor and ceiling using a particular type of finishes
A_{fa}	=	Wall length and area of floor and ceiling using a particular type of finishes
A_{ft}	=	Total wall length and area of floor and ceiling
C	=	Points for simple designs (Table 4)

Architectural Buildable Features Points	=	Points for the use of buildable designs/features such as standard components/design parameters at both project and industry level (Table 4)
A_m	=	A_{ma} / A_{mt}
A_m	=	Percentage of total area using a particular MEP system
A_{ma}	=	Area using a particular MEP system
A_{mt}	=	Total qualifying area of MEP system (Table 5)
M_N	=	Maximum allocated points for MEP System (Table 5)
MEP Buildable Features Points	=	Points for the use of buildable designs/features such as use of mechanical connections for prefabricated MEP modules and industry standard pump skid sizes (Table 5)
I	=	Maximum allocated points for Innovations and Others

[#] *points are capped at S_N*

[@] *points are capped at A_N*

^ *points are capped at M_N*

[*] *points are capped at I*

The Buildable Design Score for superstructure works of a project which consists of more than one building should be computed by multiplying the respective Buildable Design Score for superstructure works of the individual building with its percentage of the total floor area of that building in the project. That is,

B-Score $_{project}$ = Sum of [B-Score $_{building}$ x (A_{st}) $_{building}$ / (A_{st}) $_{project}$]

EXPLANATORY NOTES TO BUILDABLE DESIGN SCORE FORMULA

(a) Buildable Design Score of Structural System

The score for the structural system is based on the following:

Method for computation: $[\sum(A_s x S_N)]$ + Structural Buildable Features Points

A_s : The extent to which a particular structural system is used. This is expressed as a percentage of the total floor area of the building.

S_N : Points allocated for the particular structural system. The points allocated for the various structural systems are given in Table 3.

Structural Buildable Features Points: Various structural buildable features such as prefabricated reinforcement cages for beams, columns and walls, large panel slabs, integrated precast components, mechanical connections, precast slab with lattice girder reinforcement and use of high strength concrete are given points as shown in Table 3.

All structural systems used must be accounted for. If a combination of systems is used, then the contribution of each system is computed and summed up to arrive at the score.

The total floor area for superstructure works is the total floor area constructed in the project including the roof area (projected area) but excluding the areas for basement and first storey. The total floor area for basement works includes the first storey area.

The maximum Buildable Design Score for structural systems inclusive of structural buildable features is based on the category of building works as shown in Table 1.

(b) Buildable Design Score of Architectural System

The score for the architectural system is based on:

Method for computation : $[\sum(L_w \text{ x } A_N)] + [\sum(A_f \text{ x } A_N)]$ + C + Architectural Buildable Features Points

L_w : The extent to which a particular wall system is used. This is expressed as a percentage of the total wall length of the building.

A_f : The extent to which a particular type of finish is used. This is expressed as a percentage of the total wall length and area of floor and ceiling of the building.

A_N : Points allocated for the particular wall system and finishes. The points allocated for the various wall systems and types of finishes are given in Table 4.

C : Points given to simple building designs without high voids and complex design forms. Depending on the design simplicity, different points are given up to a maximum of 5 points as shown in Table 4.

Architectural Buildable Features Points: Various architectural buildable designs/features such as horizontal grids, PPVC modules in modular dimensions, horizontal design repetition of unit layouts, repetition of PPVC modules and PBUs, standard door structural openings and standard PBU sizes are given points as shown in Table 4.

All wall systems and finishes must be accounted for. If a combination of systems/finishes is used, then the contribution of each system/type of finish is computed and summed up to arrive at the score.

The total wall length for superstructural works includes all external and internal walls starting from the first storey. The total wall length for basement works includes all internal walls at basement but exclude external basement wall for earth retaining purpose.

The maximum Buildable Design Score for wall systems inclusive of architectural buildable features is based on the category of building works as shown in Table 1.

(c) Buildable Design Score of MEP System

The score for the MEP system is based on:

Method for computation: $[\sum(A_m \times M_N)]$ + MEP Buildable Features Points

A_m : The extent to which a particular MEP system is used. This is expressed as a percentage of the total qualifying area of the prefabricated MEP system. Criteria for determining the qualifying area of prefabricated MEP system is as shown in Table 5A.

S_N : Points allocated for the particular MEP system. The points allocated for the various MEP systems are given in Table 5.

MEP Buildable Features Points: Various MEP buildable designs/features such as mechanical connections for MEP components and industry standard sizes for prefabricated pump skids are also given points as shown in Table 5.

All MEP systems must be accounted for. If a combination of systems is used, then the contribution of each system is computed and summed up to arrive at the score.

The maximum Buildable Design Score for MEP systems inclusive of MEP buildable features is based on the category of building works as shown in Table 1.

(d) Buildable Design Score of Innovation and Others

Points are given for the adoption of innovative systems and components. Examples include prefabricated organic components (e.g. precast wavy façade), Prefabricated Kitchen Unit (PKU), Prefabricated Common Toilet (PCT), high strength / lightweight materials (e.g. high strength steel reinforcement) and innovative structural connections. Please seek BCA's advice on the points to be allocated.

Points are also given for prefabricated components, PPVC modules, PBUs and prefabricated MEP systems produced or fabricated in facilities accredited under the Precaster Accreditation Scheme (PAS) or respective Manufacturer Accreditation Scheme (MAS).

The maximum overall Buildable Design Score is capped at 120 points.

3 REQUIREMENTS AND ACCEPTANCE FRAMEWORK FOR PREFABRICATED BATHROOM UNITS (PBU)

This section covers the requirements and acceptance framework for Prefabricated Bathroom Unit (PBU) systems that are to be adopted for all residential (non-landed) and residential non-landed component of mixed-use developments. The minimum number of PBUs to be adopted at each of these developments shall be 65% of the total number of bathroom units.

3.1 Requirements for Prefabricated Bathroom Units (PBU)

3.1.1 Prefabricated Bathroom Unit (PBU)

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

3.1.2 Strength and Robustness of Wall Panels

(a) For PBU with wall panels manufactured with non-concrete or lightweight concrete materials, the wall panels are to be tested in accordance to the Specification for performance requirements for strength and robustness (including methods of test) for partition walls – SS492:2001 to achieve a minimum grade of Medium Duty as well as other test standards as mentioned in BCA website at https://www1.bca.gov.sg/buildsg/productivity/design-for-manufacturing-and-assembly-dfma/performance-requirements-for-prefabricated-bathroom-units-pbu.

(b) The wall panels should not be susceptible to corrosion.

3.1.3 Access to Utilities for Maintenance, Repair and Replacement

Access panels must be provided at the ceiling within the PBU to provide access for maintenance, repair and replacement of overhead services and utilities.

3.1.4 Replacement of Tiles

The PBU must allow for tile replacement to be done via hacking with chisel and hammer, or their equivalent tools, without resulting in damage to the wall panels or backing board.

3.1.5 Provision for Barrier-Free Accessibility design requirements

(a) For PBU with wall panels manufactured with non-concrete or lightweight concrete materials, provision shall be made on the wall panels for future installation of grab bars in the prefabricated bathroom unit.

(b) Information such as the location for future installation of grab bars and the installation method statement shall be included in the homeowner user manual (see item 3.1.7).

3.1.6 Manufacturer's Label

A manufacturer's label measuring 6cm by 10cm of a waterproof and rustproof material is to be affixed within the interior of the PBU with the following information on it:

(a) Date of manufacture in the following format: Month/Year
(b) Name of manufacturer
(c) Company address of manufacturer
(d) Contact number of manufacturer
(e) Material of wall panel
(f) Material of floor pan

3.1.7 Homeowner User Manual

A user manual containing the following list of information shall be provided to homeowners upon the handing over of the unit:

(a) <u>General information about the PBU</u>
- (i) Introduction to the PBU
- (ii) Safety notices
- (iii) Instructions for use

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

(c) <u>Layout of the PBU</u>
- (i) General layout of the PBU
- (ii) Locations of concealed services *(to provide a detailed as-built drawing indicating the routing of all mechanical, electrical and plumbing services that are embedded within or behind the bathroom walls)*
- (iii) Location of the manufacturer's label

(d) <u>Cleaning and maintenance advice</u>
- (i) Internal fittings, tiles and accessories
- (ii) Floor trap
- (iii) Ceiling access panels
- (iv) Access to vertical stack

(e) Alteration, repair and replacement works
   (i) Replacement of accessories/installation 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
   (vi) Method statement on maintenance of stack pipes from inside the PBU, with considerations for reinstating wall panels with compatible material, waterproofing and tiling works

3.2 Acceptance Framework for Prefabricated Bathroom Units (PBU)

The acceptance framework consists of two parts – the Building Innovation Panel (BIP) and the PBU Manufacturer Accreditation Scheme (PBU MAS).

3.2.1 Under the acceptance framework for PBU systems, PBU suppliers and manufacturers are required to submit their applications and proposals to the Building Innovation Panel (BIP). There will be two separate evaluation stages under the BIP. Stage 1 consists of a PBU Screening Panel chaired by BCA and other industry representatives, who will be tasked to evaluate the design and materials used for each individual PBU system. Once the PBU system is accepted by the PBU Screening Panel (Stage 1), the BIP Secretariat will then coordinate submissions to the remaining regulatory agencies under the BIP and facilitate early resolution of outstanding issues between the applicant and the respective regulatory agencies (Stage 2).

3.2.2 A letter of In-Principle Acceptance (IPA) will be granted to the PBU supplier/manufacturer if acceptances are obtained from both the PBU Screening Panel (Stage 1) and the relevant participating regulatory agencies (Stage 2). The accepted PBU systems and their respective suppliers/manufacturers are listed in BCA website at https://www1.bca.gov.sg/buildsg/productivity/design-for-manufacturing-and-assembly-dfma/list-of-pbu-suppliers-that-meet-the-performance-requirement

3.2.3 In addition, the fabrication facilities producing PBU systems which have been accepted through the BIP will be required to be accredited under the PBU MAS, which is managed by the Singapore Concrete Institute (SCI) as part of the effort to promote greater self-regulation by the industry. The accreditation criteria were jointly developed by SCI and BCA. The production of PBUs for the purpose of preparing for Part 2: Plant Audit under the PBU MAS can only commence after the date of issuance of Provisional Certificate under the PBU MAS. The PBU manufacturer is required to notify BCA for Part 2: Plant Audit. Installation of PBUs at site can only commence after the date of issuance of Certificate of Accreditation for the PBU fabrication facility.

Further details on the accreditation scheme can be found at www.scinst.org.sg.

4 REQUIREMENTS AND ACCEPTANCE FRAMEWORK FOR PREFABRICATED PREFINISHED VOLUMETRIC CONSTRUCTION (PPVC)

This section covers the requirements and acceptance framework for Prefabricated Prefinished Volumetric Construction (PPVC) systems.

The coverage of PPVC adoption shall be computed based on the total super-structural floor area of the building. Total super-structural floor area refers to the total constructed floor area of the building consisting of the ground floor and all floors above the ground floor, but excluding any floor area constructed for use as a roof or car park. Where applicable, the super-structural floor area shall also exclude:

(a) environmental deck
(b) void deck (for public housing projects)
(c) swimming pool
(d) landscaped areas including sky terrace
(e) hotel lobby

4.1 Definition

"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.

4.2 Requirements for Prefabricated Prefinished Volumetric Construction

The volumetric modules used for PPVC shall comply with the following requirements:

<u>Minimum level of finishing and fittings to be completed off-site</u>

4.2.1 The extent of finishing and fittings to be completed off-site for the volumetric modules shall comply with the minimum levels stipulated in Table 1. Where any deviation from these minimum levels is necessary, prior approval must be sought from BCA.

Table 1: Minimum level of finishing and fittings to be completed off-site

Element	Minimum level of completion off-site
Floor finishes	80%
Wall finishes	100%
Painting	100% base coat, only final coat is allowed on-site
Window frame & Glazing	100%
Doors	100%, only door leaves are allowed for on-site installation
Wardrobe	100%, only doors are allowed for on-site installation
Cabinet	100%, only doors are allowed for on-site installation
M&E including water & sanitary pipes, electrical conduits & ducting	100%, only equipment is allowed for on-site installation
Electrical sockets and light switches	100%, only light fittings are allowed for on-site installation

<u>Water tightness and prevention of corrosion where steel is used as the primary structural material</u>

4.2.2 The steel shall be galvanised in accordance to ASTM A 123/A 123M or alternative equivalent standards.

4.2.3 The volumetric modules shall be designed and fabricated to:

(a) prevent water from entering the modules (e.g. by means of waterproofing membrane or other means at the joints and gaps between the modules); and

(b) allow any water in between the volumetric modules and façade, and in between the modules to be properly discharged and drained completely.

4.2.4 Floor areas intended to be wet (e.g. bathrooms, kitchens) and areas that could be potentially exposed to water (e.g. fire sprinkled areas) shall be treated with waterproofing membrane to ensure water-tightness.

4.3 Acceptance Framework for Prefabricated Prefinished Volumetric Construction (PPVC)

The acceptance framework consists of two parts – the Building Innovation Panel (BIP) and the PPVC Manufacturer Accreditation Scheme (PPVC MAS).

4.3.1 Under the acceptance framework for PPVC systems, PPVC suppliers and manufacturers are required to submit their applications and proposals to the Building Innovation Panel (BIP).

4.3.2 The PPVC system and the in-built bathrooms (if any) shall comply with the requirements of the BIP. The accepted PPVC systems including the in-built bathrooms (if any) and their respective suppliers/manufacturers are listed in BCA website at https://www1.bca.gov.sg/buildsg/productivity/design-for-manufacturing-and-assembly-dfma/list-of-suppliers-manufacturers-that-meet-the-ppvc-performance-requirement. Relevant letters of In-Principle Acceptance (IPA) will also be issued to the PPVC supplier/manufacturer.

4.3.3 In addition, the fabrication facilities producing PPVC systems which have been accepted through the BIP will be required to be accredited under the PPVC MAS, which is managed by the Singapore Concrete Institute (SCI) as part of the effort to promote greater self-regulation by the industry. The accreditation criteria were jointly developed by SCI and BCA. Further details on the accreditation scheme can be found at www.scinst.org.sg.

5 REQUIREMENTS FOR ADVANCED PRECAST CONCRETE SYSTEM (APCS)

This section covers the minimum requirements for Advanced Precast Concrete System (APCS) when adopted for buildings.

APCS refers to a precast construction method that:

(a) adopts precast concrete components, and

(b) applies 4 features (each with ≥ 65% coverage) under the 3S principles of Standardisation, Simplicity and Single Integrated Elements as shown in the Table below.

Table 1: APCS Features under the 3S Principles

Feature	Prefabricated components	Denominator (within precast slab area)	Unit
1	**Integrated precast components (comprising at least 2 structural / architectural elements)** (e.g. double bay façade wall, beam-façade wall, multi-tier column/wall, precast household shelter (HS), precast refuse chute, prefabricated bathroom unit, prefinished façade walls, precast external wall with cast-in windows)	All columns / walls / façade walls / household shelters / refuse chutes / bathrooms	No. <u>or</u> Length for walls
2	**Mechanical connection for precast column/ precast wall** (horizontal joints) (e.g. column shoes, grouted sleeves, spiral connectors)	All columns / walls	No. <u>or</u> Length for walls
3	**Mechanical connection for precast beam** (e.g. telescopic beam connectors, grouted sleeves) / **Integrated prefabricated column and beam junction** (e.g. Lotus-Root system, slim floor system (e.g. Deltabeam))	All beams	No.
4	**Mechanical connection for precast wall** (vertical joints) (e.g. flexible loops)	All façade and parapet walls	Length
5	**Mechanical connection for other precast components** (e.g. mechanical connections for parapet walls, staircases*) **Staircase flight and landing slabs shall be in precast concrete*	All parapet walls / staircases	No. <u>or</u> Length for walls
6	**Large precast panel slab** (e.g. hollow core slab, double T slab, precast plank) ≥ 2.4m width	Total precast slab area	m^2

NOTE:

(1) The examples in Table 1 are not exhaustive

(2) Where "/" is indicated for the denominator, only 1 type of prefabricated component (e.g. column or wall) is to be used for the computation of coverage per feature.

6 COMPUTATION ON LEVEL OF USE OF PREFABRICATION SYSTEMS

This section covers the computation on the level of use of prefabrication systems. The use of the following systems as found in the Buildable Design Appraisal System (BDAS) would constitute towards the overall prefabrication level for structural systems and architectural wall systems respectively in a building design:

6.1 Structural Systems

(i) Prefabricated Prefinished Volumetric Construction (PPVC)
(ii) Mass Engineered Timber (MET)
(iii) Structural steel
(iv) Advanced Precast Concrete System (APCS)
(v) Hybrid Structural steel/Precast Concrete/MET
(vi) Prefabricated column/wall, prefabricated beam and prefabricated slab
(vii) Prefabricated beam and prefabricated slab
(viii) Prefabricated column/wall and prefabricated slab
(ix) Prefabricated slab only

The sum of each of the percentage of use of the above structural systems (measured by floor area), where applicable, would result in the prefabrication level of the structural systems adopted in the project.

6.2 Architectural Wall Systems

(i) PPVC
(ii) Prefabricated Bathroom Unit (PBU)
(iii) Prefabricated and prefinished wall with MEP services
(iv) Prefabricated and prefinished wall / off-form precast wall
(v) Curtain wall / full height glass
(vi) Drywall
(vii) Prefabricated railing
(viii) Precast concrete wall
(ix) Lightweight concrete panel

The sum of each of the percentage of use of the above architectural wall systems (measured by length), where applicable, would result in the prefabrication level of the architectural wall systems adopted in the project.

6.3 Mechanical, Electrical and Plumbing (MEP) Systems

The level of Prefabricated MEP systems is computed based on the total area of prefabricated MEP systems including vertical modules, horizontal modules and plant modules over the total qualifying area. The computation of qualifying area and prefabricated area of prefabricated MEP system is as detailed in Table 5A – Computation of Qualifying Area and Prefabricated Area of Prefabricated MEP Systems.

7 MINIMUM REQUIREMENTS FOR DEVELOPMENTS ON GOVERNMENT LAND SALES (GLS) SITES

This section covers the requirements on the minimum level of use of DfMA technologies or prefabrication systems for GLS sites stipulated with productivity requirements, including all industrial developments with GFA of 5,000m² or more built on Industrial GLS. The land parcels selected are gazetted and may be found in the Building Control (Buildability and Productivity) Regulations.

Table 1: Productivity Requirements for GLS Sites

<table>
<tr><th>GLS Sites</th><th>Productivity Requirements</th></tr>
<tr><td>Residential Non-landed and residential non-landed component of mixed-use developments on GLS sites</td><td>For all sites, the minimum number of Prefabricated Bathroom Units (PBUs) to be adopted at each development shall be 65% of the total number of bathroom units. The requirements and acceptance framework for PBU systems are spelt out in Section 3.</td></tr>
<tr><td>Commercial office developments on GLS sites</td><td>Selected office sites are required to meet the following requirements:
<table>
<tr><th>DfMA Technology</th><th>Level of Adoption</th></tr>
<tr><td>Structural Steel</td><td>Min. 80%
of total office area</td></tr>
</table></td></tr>
<tr><td>All industrial developments with GFA of 5,000m² or more on GLS sites</td><td>The minimum prefabrication level for both structural systems and architectural systems must be met. The computation method for prefabrication level is spelt out in Section 6.
<table>
<tr><th>Minimum Prefabrication Level</th><th>5,000 m2 ≤ GFA < 25,000 m²</th><th>GFA ≥ 25,000 m²</th></tr>
<tr><td>Structural System</td><td>25%</td><td>40%</td></tr>
<tr><td>Architectural System</td><td>45%</td><td>60%</td></tr>
</table></td></tr>
</table>

7.1 PPVC

For selected residential non-landed, hotel or mixed-use GLS sites with residential non-landed component, the minimum level of use of PPVC shall be 65% of the total super-structural floor area of (i) the building or the component of the building that is a residential non-landed building, or (ii) the building, or the aggregate of the component of the building that is a hotel building and the component of the building that is a residential non-landed building, as the case may be. The requirements and acceptance framework of PPVC systems are spelt out in Section 4.

7.2 Structural Steel

For selected office GLS sites, the minimum level of use of structural steel construction for buildings constructed for use solely or partly as an office shall be 80% of the total office floor area of a building.

Structural steel construction refers to the construction method whereby a building or part of the building is constructed using composite steel, concrete deck floors that are connected to steel beams or steel trusses, and supported by steel components, composite steel columns or precast concrete columns.

Total office floor area, in relation to a building, refers to the total super-structural floor area of the building less any floor area that is not constructed for use as an office.

8 EXAMPLES ON COMPUTING BUILDABLE DESIGN SCORE

8.1 A SINGLE BLOCK BUILDING PROJECT

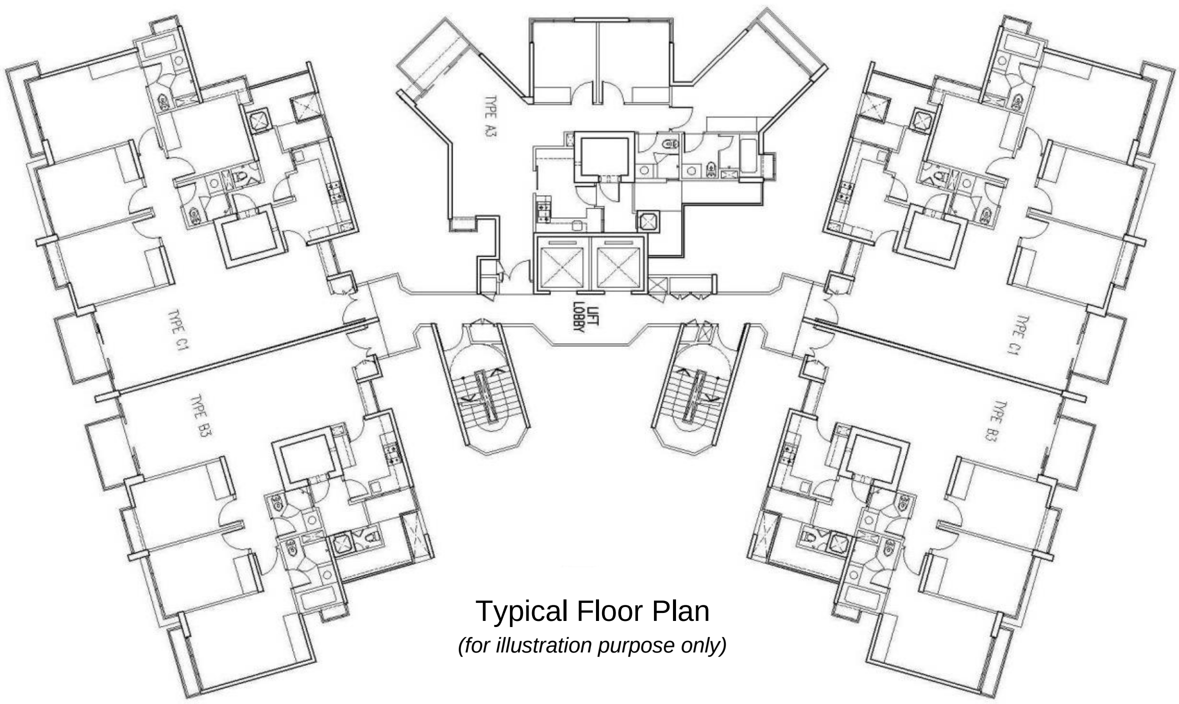
A. Project Information

- 1 block of 18-storey high private residential flats
- No basement
- 5 residential units per storey
- For simplicity, assume typical floor layout for each floor, except 1st storey and roof and there are no high voids and complex form
- Assume floor-to-floor height of 3.15m, except 1st storey, which is 4m high
- For area of building:

Total floor area of residential units	= 18 x 645.90m²	= 11,626.20m²
Total floor area of Lift Lobby	= 18 x 102.40m²	= 1,843.20m²
Roof area (assume same as typical floor)		= 748.30m²
A_{st}: Total floor area of building including roof area		= 14,217.70m²

B. Buildable Design Score Formula

B-Score = {[∑(A_s x S_N)] + Structural Buildable Features Points} +
{[∑(L_w x A_N)] + [∑(A_f x A_N)] + C + Architectural Buildable Features Points} +
{[∑(A_m x M_N)] + MEP Buildable Features Points} + I



Typical Floor Plan

(for illustration purpose only)

Area of residential units per floor	=	129.18 x 5
	=	645.90 m²
Lift lobby area per floor	=	102.40 m²
Typical floor area	=	645.90 + 102.40
	=	748.30 m²

Design based on Advanced Precast Concrete System with wall combination of precast walls and drywall

DESCRIPTION	ALLOCATED POINTS	AREA (m^2) or LENGTH (m)	COVERAGE (%)	BUILDABLE DESIGN SCORE
Pre-requisites				
(1) Floor mesh			80%	
(2) Repetition of typical floor height in 1.5M			100%	
(3) Precast staircase for typical storeys			90%	
(4) Drywall partition (all internal dry areas excluding party wall / toilet wall / kitchen wall)		1,963.90 m	18.0%	
(5) Precast household shelter			100%	
(6) Industry standard door structural openings			90%	
Structural System				
(1) Advanced Precast Concrete System (APCS) for apartment area + Roof with: a. 65% Integrated precast components b. 65% Mechanical connection for precast column/wall c. 65% Mechanical connection for precast wall d. 65% Large panel slab A_{sa} = 19 x 645.90 = 12,272.10 m^2 A_{st} = 14,217.70 m^2	S_N = 32	12,272.10 m^2	86.32%	27.62
(2) RC beam/slab for lift lobby area +Roof A_{sa} = 19 x 102.40 = 1,945.60 m^2 A_{st} = 14,217.70 m^2	S_N = 10	1,945.60 m^2	13.68%	1.37
Structural Buildable Features				
(1) Industry standard precast household shelter (3 most common sizes)	S_N = 2.0	-	65%	2.00
Structural System Sub-Total (A)				**30.99**

DESCRIPTION	ALLOCATED POINTS	AREA (m^2) or LENGTH (m)	COVERAGE (%)	BUILDABLE DESIGN SCORE
Architectural System				
Architectural Wall System				
(1) Prefabricated Bathroom Unit (PBU)	A_N = 29.0	650.00 m	6.0%	1.74
(2) Curtain wall, full height glass and railing	A_N = 26.0	1,125.90 m	10.3%	2.68
(3) Precast concrete wall	A_N = 26.0	5,204.20 m	47.7%	12.40
(4) Cast in-situ RC wall (Staircase and lift shaft)	A_N = 16.0	885.00 m	8.1%	1.30
(5) Brickwall	A_N = 0	1,080.20 m	9.9%	0.00
Sub-Total (B1) (Including 1,963.90m wall length of drywall of under 'Pre-requisites')		**10,909.20 m**	**100%**	**18.12**
Architectural Finishes				
(1) Prefabricated Bathroom Unit (PBU)	A_N = 12.0	Wall Length: 650 m Floor Area: 306 m^2	3.17%	0.38
(2) Prefabricated and prefinished wall/floor, curtain wall, glass wall partition	A_N = 9.0	Wall Length: 1,125.90 m	3.74%	0.34
(3) Prefinished ceiling	A_N = 7.0	Ceiling Area: 10,674.3 m^2	35.42%	2.48
(4) Vinyl flooring 17 storeys x 645.90 m^2	A_N = 7.0	Floor Area: 10,980.30 m^2	36.43%	2.55
(5) Skim coat and paint finish	A_N = 4.0	Wall Length: 5,205.20 m	17.27%	0.69
(6) Plaster and other finishes e.g. tiles	A_N = 0.0	Wall Length: 1,198.60 m	3.97%	0
Sub-Total (B2)		**30,140.3**	**100.00%**	**6.44**
Architectural Buildable Features				
(1) Simple design				
- Without high voids	A_N = 2.0			2.00
- Without complex form	A_N = 3.0			3.00
(2) Horizontal design repetition of unit layouts - Repetition ≥ 35	A_N = 3.0			3.00
(3) Repetition of PBUs - Repetition ≥ 40	A_N = 4.0		80%	4.00
(4) Industry standard PBUs (3 most common sizes)	A_N = 2.5		80%	2.50
Sub-Total (B3)				**14.5**
Architectural System Sub-Total (B = B1 + B2 + B3)				**39.06**

DESCRIPTION	ALLOCATED POINTS	AREA (m^2)	COVERAGE (%)	BUILDABLE DESIGN SCORE
MEP System (1) Prefabricated MEP vertical modules - Water and gas risers, hose reel risers (2) Prefabricated MEP plant modules **MEP Buildable Features** (1) Industry standard prefabricated pump skid sizes for water and firefighting services	M_N = 6.0 M_N = 6.0 M_N = 1.0		50% 80% 80%	3.0 4.8 1.0
MEP System Sub-Total (C)				**8.80**
Innovations and Others (1) Precast components produced in facilities accredited under Precaster Accreditation Scheme (PAS) (2) PBUs manufactured in facility accredited under PBU Manufacturer Accreditation Scheme (PBU MAS) **Innovations and others Sub-Total (D)**	I = 2.0 (max)			2.0 **2.00**
Total B-Score (A + B + C + D) = (30.99 + 39.06 + 8.80 + 2.00)				**80.85 (round to 81 points)**

8.2 A MULTI-BLOCK BUILDING PROJECT

A. Project Information

This project consists of 8 blocks of buildings: -

- 3 blocks of 3-storey high workshop (Block A, B & C)
- 2 blocks of 2-storey high workshop (Block D & E)
- 1 block of 2-storey high multi-purpose hall (Block F)
- 1 block of 2-storey high classroom (Block G)
- 1 block of 2-storey high classroom cum administration (Block H)

A_{st}, total floor area including roof (projected area), of each building is as below:

- Block A, B & C A_{st} = 2,700m² per building
- Block D A_{st} = 3,000m²
- Block E A_{st} = 2,400m²
- Block F A_{st} = 2,600m²
- Block G A_{st} = 1,000m²
- Block H A_{st} = 3,600m²

Overall project A_{st} = 20,700m²

B. Buildable Design Score

The Buildable Design Score (B-Score) for the respective blocks is as follows:

- Block A : B-Score = 72.0 $(A_{st})_{bldg} / (A_{st})_{proj} = 0.13$
- Block B : B-Score = 72.0 $(A_{st})_{bldg} / (A_{st})_{proj} = 0.13$
- Block C : B-Score = 72.0 $(A_{st})_{bldg} / (A_{st})_{proj} = 0.13$
- Block D : B-Score = 74.0 $(A_{st})_{bldg} / (A_{st})_{proj} = 0.14$
- Block E : B-Score = 73.0 $(A_{st})_{bldg} / (A_{st})_{proj} = 0.12$
- Block F : B-Score = 75.0 $(A_{st})_{bldg} / (A_{st})_{proj} = 0.13$
- Block G : B-Score = 63.2 $(A_{st})_{bldg} / (A_{st})_{proj} = 0.05$
- Block H : B-Score = 76.2 $(A_{st})_{bldg} / (A_{st})_{proj} = 0.17$

The Buildable Design Score of the project is computed as below:

B-Score $_{proj}$ = Sum of [B-Score $_{bldg}$ x $(A_{st})_{bldg} / (A_{st})_{proj}$]

= **73**

Annex B

CONSTRUCTABILITY APPRAISAL SYSTEM

1 INTRODUCTION

The Constructability Appraisal System (CAS) was developed by the Building and Construction Authority as a means to measure the potential impact of downstream construction methods and technologies on the productivity at site. The CAS results in a 'Constructability Score' of the building works. A project with a higher Constructability Score will result in the use of more labour efficient construction methods and technologies and therefore improve site labour productivity.

1.1 Objective

The objective of CAS is to bring about a wider use of labour-saving construction methods and technologies that can help to reduce the demand for manpower on site.

While the BDAS focuses on the use of buildable designs during the upstream design process, it is necessary to also tackle improvements in the downstream construction methods to bring about greater productivity improvements. Designers' attention to buildable designs has to be complemented with builders' adoption of labour-efficient construction technologies to bring about greater ease in construction.

The CAS thus focuses on the construction methods used during the construction phase. Through the Constructability Score, the builders' contribution to raising site productivity can be increased by encouraging them to move away from traditionally labour-intensive construction methods and switching to more labour-efficient construction processes.

1.2 Principles of Constructability

The CAS is a performance-based system with flexible characteristics that allow builders to meet the constructability requirements with the most cost-effective solution. The constructability of building works is assessed in the areas of *Structural Works, Architectural, Mechanical, Electrical and Plumbing (AMEP) Works* as well as *Site Practices*.

As structural works require the greatest manpower usage for building projects, and is usually along the critical path of a construction, a switch to a more labour efficient construction system for structural works is likely to bring about a direct improvement in site productivity.

Besides structural works, manpower is also required for architectural works and M&E works. Hence, site productivity gains could be realised if builders were to embrace the use of efficient construction methods and technologies that reduce labour usage for these areas of works.

In addition, the adoption of good site practices, such as good project and site management is also critical to enhancing site productivity performance.

1.3 Scope

The CAS therefore aims to derive productivity improvements from each of the areas of structural works, AMEP works as well as site practices.

Points are awarded based on the types of construction methods, technologies and processes adopted. Innovative construction technologies, methods and systems, and use of advanced plant and equipment that are capable of reducing manpower usage and improving site productivity are also awarded with points. The points are totaled to give the "Constructability Score" of the building works.

1.4 Rationale on Allocation of Points

1.4.1 The computation of Constructability Score for a project involves the summation of Constructability Score attained for the Structural component, AMEP component and the component on Good Industry Practices. The total Constructability Score allocated under these three components is 120 points

1.4.2 The highest weightage is given to the Structural component, i.e. 50% or 60 points of the total Constructability Score. The Structural component of the Constructability Score focuses on the builder's choice of external access systems and formwork systems as these take up the bulk of the total manpower needed for structural works.

1.4.3 The other 50% of the Constructability Score is allocated to AMEP and Good Industry Practices. For the AMEP component, points are awarded if builders make a conscious effort to avoid wet works such as screeding and plastering. Builders will also be assessed on their usage of labour efficient pipe works and air-con main ducting works such as pre-insulated pipework and prefabricated and pre-insulated ducts. Similarly, Good Industry Practices focuses on specific good practices such as the use of Building Information Modelling (BIM) and productivity monitoring systems implemented on site to achieve higher productivity.

1.4.4 The allocation of points to the Structural component, the AMEP component and the Good Industry Practices component is to bring about a greater adoption of labour efficient advanced construction methods and processes. In some areas, the traditional construction methods are given much lower points under the Constructability Score to dis-incentivise their use.

2 HOW TO USE THE CONSTRUCTABILITY APPRAISAL SYSTEM

2.1 Components of the Constructability Appraisal System (CAS)

The CAS provides a method to compute the Constructability Score of a project. It consists of three main components:

(a) the Structural System;

(b) the Architectural, Mechanical, Electrical & Plumbing (AMEP) System; and

(c) Good Industry Practices

The Constructability Score is expressed as:

Constructability	=	Constructability Score of Structural System
Score of	+	Constructability Score of AMEP System
Building Works	+	Constructability Score of Good Industry Practices

(a) Constructability Score of the Structural System

A builder could use different external access systems and formwork systems or a combination of each of these systems for different parts of the building so as to achieve the most practical and cost-effective approach to meeting the constructability requirement.

The Constructability Score for a particular external access system is the product of the percentage of building perimeter using this external access system and its corresponding allocated points. The Constructability Scores for different external access systems adopted are then summed up to arrive at the Constructability Score of the total external access system. The points allocated to different external access systems are given in Table 1 and the total points achievable under this section are 15 points.

The Constructability Score for a particular formwork system is the product of the percentage of area using the formwork system and its corresponding allocated points. For vertical formwork, the area would be the contact area of the formwork system whereas for horizontal formwork, the area would be the floor area. The Constructability Scores for different formwork systems adopted are then summed up to arrive at the Constructability Score of the total formwork system. All formwork systems must be accounted for, except for those used in the basement / sub-structural works. Formwork systems are classified into different bands according to their productivity as assessed and the points allocated to the different formwork systems are given in Table 1. The total points achievable under this section are 30 points.

Constructability points are also given to structural innovative methods, systems, processes and plant and equipment that contribute to labour saving on site. Some specific items under this section are given in Table 1. Direct points are awarded if the usage of these items meets the stipulated criteria and conditions. Points could also be awarded to other innovative construction technologies and methods which reduce labour usage, subject to BCA's assessment. The total points achievable under this section are 15 points.

The contribution of Constructability Scores from the total external access system, the total formwork system and structural innovative systems are summed up to arrive at the Constructability Score of the Structural System. The maximum Constructability Score for Structural System is 60 points.

(b) Constructability Score of AMEP System

Under the architectural portion, Constructability Scores for the use of screed-less floor and unplastered RC wall are given only if these are specifications not stipulated in the tender drawings. For these two items, the Constructability Scores are computed by multiplying the percentage of floor area with no screeding or the percentage of wall length with no plastering works and their corresponding allocated points.

For other AMEP items namely spray painting, pre-insulated pipework, prefabricated and pre-insulated ducts, flexible water pipes and mechanical joints for M&E piping, the use of these items will be awarded with points directly if the corresponding stipulated conditions are met. The points allocated to the various AMP systems are given in Table 2 and the total points achievable under this section are 25 points.

Constructability points are also given to AMEP innovative methods and systems that contribute to labour saving on site. Direct points are awarded if the usage of these items meets the stipulated criteria and conditions. The total points achievable under this section are 20 points.

The points awarded for all the items under the AMEP component are summed up to arrive at the Constructability Score of the AMEP System. The maximum Constructability Score for AMEP System is 45 points.

(c) Constructability Score of Good Industry Practices

In this section, direct points are awarded to good industry practices adopted at site which help to improve construction productivity. Points are given for each good industry practice adopted and these are summed up to give the score, up to a maximum of 15 points. The points allocated to the various good industry practices are given in Table 3.

Table 1 Structural System

STRUCTURAL SYSTEM (MAXIMUM 60 POINTS)		
Construction Technologies / Methods	**Allocated Points**	**Computation Method**
1. External Access System (Maximum 15 points)		
(a) No external scaffold	15	$\frac{\sum \text{(Length with external access system/no external scaffold x Allocated pts)}}{\text{Total Building Perimeter}}$
(b) Self-climbing perimeter scaffold	15	
(c) Crane-lifted perimeter scaffold / fly cage	14	
(d) Traditional external scaffold	1	
2. Formwork System (Maximum 30 points)		
A. Vertical Contact Area		
(i) No formwork (precast construction)	15	$\frac{\sum \text{(Vertical Formwork Contact Area x Allocated points)}}{\text{Total Vertical Formwork Contact Area}}$
(ii) Traditional timber/metal formwork	1	
(I) Vertical Formwork[1]		
(i) System Formwork (Band 1)	15	
(ii) System Formwork (Band 2)	14	
(iii) System Formwork (Band 3)	13	
(iv) System Formwork (Band 4)	11	
(v) System formwork (Band 5)	8	
B. Floor Area		
(i) No formwork (precast construction)	15	$\frac{\sum \text{(Floor Area x Allocated points)}}{\text{Total Floor Area}}$
(ii) Traditional timber/metal formwork	1	
(I) Horizontal Formwork[1]		
(i) System Formwork (Band 1)	15	
(ii) System Formwork (Band 2)	14	
(iii) System Formwork (Band 3)	13	
(iv) System Formwork (Band 4)	11	
(v) System formwork (Band 5)	8	
3. Structural Innovative Systems (Maximum 15 points)		
(a) Use of self-compacting concrete	2	Points are given if usage is ≥ 5% of total superstructure concrete volume
(b) Use of hydraulic stationary placing boom for concreting	2	Points will be given once used
(c) Use of tower crane (tip load ≥ 10 tonnes at maximum reach)	5	Points will be given once used
(d) Strut free deep basement construction[2]	6 (max)	Applicable to projects with restricted site access. Normal earth slope with or without concrete lining is excluded.
(e) Any other innovations in structural systems	Points to be awarded only for high impact items that improve labour efficiency[3]	

NOTE:

(1) System formworks are grouped into bands in their respective classification according to their productivity output assessed through productivity demonstration. Each band is allocated different Constructability Points to reflect the relative efficiencies of the different system formwork. System formwork not assessed would be deemed to have the same productivity as those under the lowest band (i.e. Band 5) and be accorded with the lowest Constructability Points for system formwork.

(2) BCA will assess the extent of the strut free basement construction and determine the number of points to be awarded.

(3) BCA will assess the impact of the innovative system on labour usage and determine the number of points to be awarded.

EXPLANATORY NOTES TO TABLE 1

(a) Table 1 has been arranged into 3 main sections of external access system, formwork system and innovative systems with their respective point allocation.

(b) Different system formwork have varying productivity performance. To determine the productivity of each system formwork, BCA will carry out a productivity assessment for each system formwork using a standard layout template. The various system formwork are classified into vertical formwork or horizontal formwork. Depending on the productivity outcome, the different system formwork are then grouped into bands in their respective classification. Each band is allocated different Constructability Points to reflect the relative efficiencies of the different system formwork. In the event that a particular formwork system has not been assessed on its productivity, this system formwork shall be taken to have the same productivity as system formwork classified under Band 5 and be awarded with the lowest Constructability Points.

For ease of reference, BCA will publish the bands and allocated Constructability Points of the various system formwork which have been assessed on their productivity performance on BCA's website. The published data will be updated regularly.

(c) Some specific items with points allocated have been listed in Table 1 under Structural Innovative Systems. For any other innovations proposed by the builder that are not stated in Table 1, BCA shall determine the points to be awarded or not to be awarded. For such cases, the builder is advised to seek BCA's comments early.

Table 2 Architectural, Mechanical, Electrical & Plumbing System (AMEP)

ARCHITECTURAL, MECHANICAL, ELECTRICAL & PLUMBING SYSTEM (AMEP) (MAXIMUM 45 POINTS)		
Construction Technologies / Methods	**Allocated Points**	**Computation Method**
1. Architectural		
(a) No screeding on floors (not stipulated in tender drawing): (i) To immediately receive tile/stone finish using thin bed adhesive (ii) Carpet or raised floor finishing	5	Floor Area with no screeding x Allocated points Total Area (excluding wet areas[1])
(b) RC walls left unplastered to receive (not stipulated in tender drawing): (i) Tile/Stone (ii) Wallpaper (iii) Paint (skim coat allowed)	5	RC Wall* Length with no plastering x Allocated points Total RC Wall Length* * *Refers to RC walls with finishing including tile/ stone, wallpaper & paint*
(c) Use of spray painting	3	Points are given if usage ≥ 50% of total internal painted area
2. Mechanical, Electrical & Plumbing (MEP)		
(a) Pipe Works (i) Pre-insulated chilled water pipes	3	Points are given if usage ≥ 80% of total pipe length
(b) Air-Con Ducting (i) Prefab ducts OR (ii) Prefab & Pre-insulated ducts	3 6	Points are given if usage ≥ 80% of total duct length
(c) Use of flexible pipes[2] for domestic water system	3	Points are given if usage ≥ 80% of total pipe length
(d) Use of mechanical joints for M&E piping	2	Points are given if usage ≥ 80% of total pipe length
3. AMEP Innovative Systems (Maximum 20 points)		
(a) Use of ceiling inserts	2	Points are given if once used for at least one complete floor
(b) Prefab plant / piping modules	3	Points are given once used for at least one plant room
(c) Any other innovations in AMEP systems	Points to be awarded only for high impact items that improve labour efficiency[3]	

NOTE:

(1) Wet areas shall include bathroom, kitchen, utility room and balcony areas

(2) Flexible pipes include Crosslinked Polyethylene (PEX) pipes

(3) BCA will assess the impact of the innovative system on labour usage and determine the number of points to be awarded.

EXPLANATORY NOTES TO TABLE 2

(a) Table 2 has been arranged into 3 main sections of architectural system, mechanical & electrical and plumbing system and innovative systems with their respective point allocation.

(b) No screeding on floors (not stipulated in tender drawing) applies to all floor areas with floor finishes.

(c) RC walls left unplastered (not stipulated in tender drawing) refer to off-form RC walls.

(d) Ceiling inserts refer to brackets or steel sections for supporting piping, conduits, cables and other M&E fittings which have been casted in-place in concrete.

(e) Prefab plant / piping modules refer to plant, pipes or ducts that are prefabricated off-site, assembled and installed in modules.

(f) Some specific items with points allocated have been listed in Table 2 under AMEP Innovative Systems. For any other innovations proposed by the builder that are not stated in Table 2, BCA shall determine the points to be awarded or not to be awarded. For such cases, the builder is advised to seek BCA's comments early.

Table 3 Good Industry Practices

GOOD INDUSTRY PRACTICES (MAXIMUM 15 POINTS)	
Description	**Allocated Points**
(a) Adopt Virtual Design and Construction (VDC) to integrate Building Information Modelling (BIM) and advanced management methods to improve site productivity:	
(i) Check for clashes between M&E services, structural provision and architectural objects (ii) Produce M&E Coordination Drawings, Architectural Shop Drawings and Concrete Body Plan for construction purposes (iii) Simulate construction schedules and resource planning	2
(iv) Implement various VDC technologies/practices to improve site productivity (v) Adopt Integrated Concurrent Engineering, Process & Production Management and Metrics as part of the construction process	3
(b) Engage BCA Certified Construction Productivity Professional (CCPP) in the project: (i) The CCPP must be engaged full-time in the said project; (ii) The CCPP is required to submit a Project Productivity Enhancement Proposal (PPE) which shall contain proposals for <u>macro (project-wide) productivity improvements</u> for the project and two new key trades' <u>micro (trade or process specific) productivity improvements</u>. The PPE must be acceptable to BCA; and (iii) The CCPP and the builder must implement these proposed productivity improvements in the project.	5
(c) Adopt a trade productivity monitoring system for whole project duration to: (i) Establish "workers' productivity norms" (ii) Conduct work studies on the processes if the productivity levels deviate from the norm (iii) Implement measures to improve productivity whenever possible	2
(d) Produce and distribute step by step work manuals for all trades and set up site mock-ups to show how works should be done properly for whole project duration for: (i) Wall installation (ii) Waterproofing (iii) Suspended ceiling installation (iv) Window installation	2
(e) Conduct monthly work study sessions, to scrutinise and improve the work process on site, as well as minimise wastage and improve productivity	1
(f) Use tools like CCTV to conduct real time monitoring on site to study resource flow, schedule and work process flow	1

Table 3 Good Industry Practices (continued)

GOOD INDUSTRY PRACTICES (MAXIMUM 15 POINTS)	
Description	**Allocated Points**
(g) Conduct the following daily: (i) Tool box meeting (every worker to be informed on his task for the day) (ii) Sub-contractors coordination meeting (to coordinate on work process and resource allocation)	1
(h) Use of scissor lift and/or personnel lift in lieu of traditional scaffold	1
(i) Use of boom lift in lieu of traditional scaffold	1
(j) Other Good Industry Practices (maximum 5 points)	5

EXPLANATORY NOTES TO TABLE 3

(a) Points would only be awarded to a builder when any of the good industry practices listed in Table 3 has been adopted throughout the duration of the project.

(b) Trade productivity has to be monitored on regular basis by the builder. A minimum of five trades must be monitored for each project. Examples of these trades are drywall installation, tiling, painting, ceiling board installation and reinforced concrete casting.

(c) CCTV equipped with real time monitoring system may be used in conjunction with BIM for scheduling and site resource planning purposes. The builder must demonstrate that a monitoring system has been set up on site and is utilised by the project team.

(d) Other Good Industry Practices specified shall be subjected to BCA's assessment and approval.

3 EXAMPLES ON COMPUTING CONSTRUCTABILITY SCORE

3.1 A residential non-landed development with 2 basements and GFA ≥ 25,000 m^2

<table>
<tr><th>Construction Technologies / Practices</th><th>Computation</th><th>Score</th></tr>
<tr><td colspan="3">Structural System (Max 60 Points)</td></tr>
<tr><td>1. External Access System (max 15 points)</td><td>• Self-climbing scaffold used for entire building perimeter
Score = 100% x 15 points = 15 points</td><td>15</td></tr>
<tr><td>2. Formwork System (max 30 points)</td><td>• Vertical formwork contact area (Band 2) is 4,000m^2
• Horizontal formwork floor area (Band 3) is 36,000m^2
• Precast columns were adopted at certain areas, with a total vertical contact area of 2,500m^2
<table>
<tr><th></th><th>Types of System</th><th>Contact area/ Floor area (m^2)</th><th>Working</th><th>Pts</th></tr>
<tr><td rowspan="2">Vertical Contact Areas</td><td>Vertical Formwork (Band 2 – 14 points)</td><td>4,000</td><td>$14 \times \frac{4000}{4000+2500}$</td><td>8.62</td></tr>
<tr><td>Precast Columns (15 points)</td><td>2,500</td><td>$15 \times \frac{2500}{4000+2500}$</td><td>5.77</td></tr>
<tr><td>Horizontal Floor Areas</td><td>Horizontal Formwork (Band 3 – 13 points)</td><td>36,000</td><td>$13 \times \frac{36000}{36000}$</td><td>13.00</td></tr>
<tr><td colspan="4">Score</td><td>27.39</td></tr>
</table>
</td><td>27.39</td></tr>
<tr><td>3. Structural innovative systems (max 15 points)</td><td>- Strut free deep basement construction</td><td>6</td></tr>
<tr><td colspan="2">Sub-total for A (max 60 points)</td><td><u>48.39</u>
<u>≥ 45 (min)</u></td></tr>
</table>

Construction Technologies / Practices	Computation	Score
Architectural, Mechanical, Electrical & Plumbing System (AMEP) (Max 45 Points)		
1. Architectural		
(a) No screeding on floors (not stipulated in tender drawing): (i) to immediately receive tile/stone finish using thin bed adhesive, (ii) carpet or raised floor finishing	• *Floor area without screed to receive tile finish is 20,000m²* • *Floor area with screed (excluding wet areas) is 8,000m²* Total floor area = 20,000 + 8,000 = 28,000m² **Score** = (20000/28000) x 5 points = 3.57 points	3.57
(b) Use of spray painting	• *Spray painting is used for more than 50% of total internal painted area*	3
2. Mechanical, Electrical & Plumbing (MEP)		
(c) Use of flexible pipes for domestic water system	• *Flexible water pipes were used for more than 80% of total pipe length*	3
	Sub-total for B (max 45 points)	<u>**9.57**</u>
C. Good Industry Practices (Max 15 points)		
Adopt a trade productivity monitoring system for whole project duration to: (i) Establish "workers' productivity norms" (ii) Conduct work studies on the processes if the productivity levels deviate from the norm (iii) Implement measures to improve productivity whenever possible		2
Produce and distribute step by step work manuals for all trades and set up site mock-ups to show how works should be done properly for whole project duration for: (i) Wall installation (ii) Waterproofing (iii) Suspended ceiling installation (iv) Window installation		2
Conduct monthly work study sessions, to scrutinise and improve the work process on site, as well as minimise wastage and improve productivity		1
Conduct the following daily: (i) Tool box meeting (every worker to be informed on his task for the day) (ii) Sub-contractors coordination meeting (to coordinate on work process & resource allocation)		1
	Sub-total for C (max 15 points)	<u>**4**</u>
Total Constructability Score = Sub-total (A) + Sub-total (B) + Sub-total (C)		<u>**64**</u> <u>**> 60 (min)**</u>

3.2 A MULTI-BLOCK BUILDING PROJECT

A. Project Information

This project consists of 3 blocks of buildings: -

- 1 block of 30-storey high office building (Block A)
- 1 block of 40-storey high residential building (Block B)
- 1 block of 45-storey high residential building (Block C)

A_{fw}, total formwork system floor area, is as below:

- Block A A_{fw} = 20,000m²
- Block B A_{fw} = 25,000m²
- Block C A_{fw} = 35,000m²

Overall project A_{fw} = 80,000m²

B. Constructability Score

The Constructability Score (CScore) for the respective blocks is as follows:

- Block A : CScore = 65 $(A_{fw})_{bldg} / (A_{fw})_{proj}$ = 16.25
- Block B : CScore = 60 $(A_{fw})_{bldg} / (A_{fw})_{proj}$ = 18.75
- Block C : CScore = 64 $(A_{fw})_{bldg} / (A_{fw})_{proj}$ = 28.00

The Constructability Score of the project is computed as below:

$$CScore_{proj} = \text{Sum of } [CScore_{bldg} \times (A_{fw})_{bldg} / (A_{fw})_{proj}]$$

$$= \underline{\mathbf{63}}$$

Annex C

REQUIREMENTS FOR OUTCOME-BASED SOLUTIONS

1 INTRODUCTION

This section covers the requirements and default Buildable Design Score and Constructability Score for projects that adopt outcome-based solutions. These solutions are applicable for large projects with GFA ≥ 25,000 m^2.

2 OUTCOME-BASED SOLUTIONS FOR PROJECTS WITH GFA ≥ 25,000 M^2

2.1 Options

Outcome-based options include deemed acceptable solutions and open option.

Deemed Acceptable Solutions

Deemed acceptable solutions for different category of building works are as spelt out in Table 1.

Table 1 Deemed Acceptable Solutions for Different Categories of Building Works/Development

<table>
<tr><th>CATEGORY OF BUILDING WORKS/ DEVELOPMENT</th><th>Deemed Acceptable Solution
(Applicable to large projects with GFA ≥ 25,000 m^2)</th></tr>
<tr><td>Public Residential (non-landed)</td><td rowspan="2">Deemed Acceptable Solution: Option 1
Structural System: Min. 65% Prefabrication Level
Architectural System: Min. 80% Prefabrication Level
MEP System: Min. 50% Prefabrication Level
System Formwork: Min. 70%

Deemed Acceptable Solution: Option 2
Min. 60% PPVC + 70% System Formwork; or
Min. 50% PPVC (5-storey and below) + 70% System Formwork</td></tr>
<tr><td>Private Residential (non-landed)</td></tr>
<tr><td>Commercial</td><td rowspan="3">Deemed Acceptable Solution: Option 1
Structural System: Min. 60% Prefabrication Level or 50% Structural Steel/APCS/MET
Architectural System: Min. 80% or 70% Prefabrication Level (for office only)
MEP System: Min. 50% Prefabrication Level
System Formwork: Min. 70%

Deemed Acceptable Solution: Option 2
Min. 60% PPVC + 50% Prefabricated MEP + 70% System Formwork</td></tr>
<tr><td>Industrial</td></tr>
<tr><td>Institutional, School and Others</td></tr>
</table>

For each of the deemed acceptable solutions, a Deemed Acceptable Proposal must be submitted. The proposal shall describe and demonstrate the extent of use of the DfMA or prefabrication technologies and system formwork to be implemented for the building works that meets the minimum requirements as spelt out in Annex A.

For mixed developments, each building use must meet the minimum requirements specified under deemed acceptable solutions.

Open Solution (applicable to large projects with GFA ≥ 25,000 m^2)

An open solution refers to a proposal which can achieve at least 25% productivity improvement. The proposal must be accompanied by a Project Productivity Improvement Plan (PPIP) of the building works which describes the extent of use and details of the innovative designs and construction techniques to be implemented for the building works for the purpose of demonstrating that the minimum 25% productivity improvement requirement over the 2010 level can be achieved.

2.1.1 PPVC, Structural Steel, APCS and MET

When a deemed acceptable solution involving a specific DfMA technology is adopted, the minimum level of adoption for the technology, namely PPVC, structural steel, APCS or MET must be met in the project. In the case of PPVC and APCS, the requirements spelt out in Section 4 and Section 5 of Annex A respectively shall apply.

2.1.2 Prefabrication Level

The minimum prefabrication level for structural systems, architectural systems and mechanical, electrical and plumbing systems must be met in the project. The computation of level of prefabricated systems is as detailed in Section 6 of Annex A.

2.1.3 System Formwork

The adoption level required for system formwork is for the remaining (i) cast in-situ floor slabs and (ii) cast in-situ walls/columns, beyond the stipulated prefabrication level.

For horizontal system formwork, the adoption level shall be computed over the total constructed floor area (CFA) of the cast in-situ slabs. For vertical system formwork, the adoption level shall be computed over the total contact area of the cast in-situ walls/columns. Both vertical and horizontal system formwork adopted must each meet the stipulated minimum adoption level of 70%.

The use of prefabricated system, such as precast or structural steel construction, beyond the stipulated requirement shall count towards meeting the stipulated minimum system formwork level. Please refer to Table 2 for illustration and Table 3 for example.

Table 2 System Formwork Requirement

System Formwork Measurement	Measurement of prefab slab/wall	System Formwork (SF) Requirement for remaining cast in-situ (CIS) area
Horizontal System Formwork **CFA of structural systems** in respect of total CFA of the superstructure works at project level	**CFA** of PPVC, and/or other prefab structural systems	**70% of the remaining CFA** outside the stipulated % of PPVC/prefab structural system *(CFA of prefab structural systems adopted beyond stipulated prefabrication level can be considered towards fulfilling SF requirement)*
Vertical System Formwork **Vertical contact area of wall systems** in respect of total vertical contact area of the superstructure wall systems at project level	**Total wall length** of PPVC and/or other prefab wall systems	**70% of the remaining vertical contact area** (remaining wall length x height) outside the stipulated % of PPVC/prefab wall system *(Vertical contact area of prefab wall systems adopted beyond stipulated prefabrication level can be considered towards fulfilling SF requirement)*

Example:

Project adopts 65% PPVC + 10% prefab structural system and 10% prefab architectural wall system

Table 3 Computation for System Formwork Requirement

System Formwork	PPVC	System Formwork (SF) Requirement for remaining cast in-situ (CIS) area
Horizontal System Formwork Total CFA: 100,000m² CFA of PPVC: 65,000m² CFA of precast slab: 4,500m	CFA of PPVC system: 65,000m² (assuming that it equates to 60% PPVC)	70% x (100,000m² – 65,000m²) = 24,500m² As prefab slab has also been adopted, horizontal system formwork requirement: 24,500 – 4,500 = 20,000m²
Vertical System Formwork Total wall length: 10,000m Wall length of PPVC: 7,000m Wall length of other prefab walls: 1,000m (assuming vertical contact area is 10,000m²)	Wall length of PPVC system: 7,000m (assuming that it equates to 60% PPVC)	70% x (10,000m – 7,000m) = 2,100m (assuming vertical contact area is 12,000m²) As other prefab walls have also been adopted, vertical system formwork requirement: 12,000m² - 10,000m² = 2,000m²

2.1.4 Open Solution – Proposal which can achieve 25% Productivity Improvement

The QP for Architectural Works, the QP for Structural Works, the PE for Mechanical Works, the PE for Electrical Works and the builder can propose innovative solutions to achieve at least 25% site productivity improvement in their project for BCA's acceptance. Submission of the open option proposals shall be made in the form of a Project Productivity Improvement Plan.

a. <u>Requirements on Project Productivity Improvement Plan (PPIP)</u>

The Project Productivity Improvement Plan (PPIP) serves to explain the design concept and for the QPs, the PEs and the Builder to substantiate that the proposed innovation/system/technology/design could achieve a productivity improvement of at least 25% (based on 2010's level) as shown below.

Table 4 2010's Productivity Level (m^2 per manday)

Category of Building	Productivity (m^2 per manday)
Public Residential (non-landed)	0.439
Private Residential (non-landed)	0.319
Commercial	0.328
Industrial	0.495
Institutional, schools and others	0.319
MRT station	

b. <u>Information to be included in the Project Productivity Improvement Plan (PPIP)</u>

To facilitate BCA's evaluation, the PPIP shall include the following:

(i) Details of the proposed designs/technologies/systems to be implemented for the building works
(ii) Level of use of buildable features, prefabricated systems and offsite finishes for the proposed construction system
(iii) Details of the proposed construction process and construction management to be implemented for the building works
(iv) Details of any innovative features to be implemented for the building works
(v) Details of how productivity improvement can be achieved

(vi) Such other documents or information as may be required by the Commissioner of Building Control.

QPs should pre-consult BCA before making building plan submission.

Please refer to Appendix for more details.

3 DEFAULT BUILDABLE DESIGN SCORE AND CONSTRUCTABILITY SCORE FOR DEVELOPMENTS ADOPTING OUTCOME-BASED SOLUTIONS

The following default scores shall be applicable for superstructure works of developments adopting outcome-based solutions in lieu of submissions of Buildable Design Score and Constructability Score.

Table 5 Default Buildable Design Score and Constructability Score for Developments with GFA ≥ 25,000m^2 adopting Outcome-based Solutions

Category of Building Works	Deemed-acceptable Solution (Applicable to large projects with GFA ≥ 25,000 m^2)				Default B-Score	Default C-Score
	Prefabricated Structural System	Prefabricated Architectural System	Prefabricated MEP System	System Formwork		
Public Residential (non-landed) or **Private Residential (non-landed)**	Min. 65%	Min. 80%	Min. 50%	Min. 70%	80	60
	Min. 60% PPVC		-	Min. 70%	82	62
	Min. 50% PPVC (5-storey and below)		-	Min. 70%		
Commercial	Min. 60% or Min. 50% Structural Steel/APCS/MET	Min. 80% or Min. 70% (for office only)	Min. 50%	Min. 70%	70	60
	Min. 60% PPVC		Min. 50%	Min. 70%	72	62
Industrial	Min. 60% or Min. 50% Structural Steel/APCS/MET	Min. 80%	Min. 50%	Min. 70%	70	60
	Min. 60% PPVC		Min. 50%	Min. 70%	72	62
Institutional, School and others	Min. 60% or Min. 50% Structural Steel/APCS/MET	Min. 80%	Min. 50%	Min. 70%	66	60
	Min. 60% PPVC		Min. 50%	Min. 70%	68	62

The default Buildable Design Score for basement works shall be 42 points if the basements are part of the projects adopting any of the outcome-based solutions.

4 SUBMISSION PROCEDURES FOR PROJECTS ADOPTING OUTCOME-BASED SOLUTIONS

The default Buildable Design Score, default Constructability Score and the accompanied proposals shall be submitted during the following stages:

- Building Plan (BP) stage
- Permit to commence structural works
- Temporary Occupation Permit (TOP)/Certificate of Statutory Completion (CSC) stage (for default Constructability Score)

4.1 Submission at BP Stage

The QP shall indicate in Form BPD_BP03 (Application for Approval of Building Plans) that the project is submitting an outcome-based proposal in lieu of a Buildable Design Score, and submit Form BPD_BS01 jointly endorsed by QP for Architectural Works, the QP for Structural Works, the PE for Mechanical Works and the PE for Electrical Works to declare the choice of outcome-based solution and acknowledge the default Buildable Design Score. Forms BPD_BP03 and BPD_BS01 can be downloaded from BCA's website at http://www1.bca.gov.sg/.

In addition to the above, the QPs must submit a Deemed Acceptable Proposal or Project Productivity Improvement Plan jointly endorsed by the QP for Architectural Works, the QP for Structural Works, the PE for Mechanical Works and the PE for Electrical Works for approval. Requirements in Table 6 serves to substantiate the outcome-based solution selected.

Table 6 Requirements for Outcome-based Proposal

Type of Outcome-based Proposal	Information and details to be included in the proposal
Deemed Acceptable Proposal comprising: • PPVC	• The floor plan of every storey that clearly marks out the structural floor area for every structural system of that storey, including the extent of use of PPVC; • The extent of finishing and fittings to be completed off-site for PPVC modules and PBUs (where applicable); • Certificate of accreditation under Manufacturer Accreditation Scheme (MAS) for PPVC system; and • Where applicable, the dimension of building components and the type and extent of use of industry standard components.

Type of Outcome-based Proposal	Information and details to be included in the proposal
Deemed Acceptable Proposal comprising: • high prefabrication level; and/or • specific DfMA technology i.e. APCS, Structural Steel, MET	• The floor plan of every storey including roof that clearly marks out the structural floor area and wall length for every structural system and wall system of that storey, type of wall finishes, and the area of every Mechanical, Electrical and Plumbing (MEP) system, including the extent of use of prefabricated systems /DfMA technology; • The elevation plan of the building that clearly marks out the structural floor area and wall length for every structural system and wall system of that storey, type of wall finishes, and the area of every MEP system, including the extent of use of prefabricated systems/DfMA technology; • Where applicable, the extent of finishing and fittings to be completed off-site for PBUs; • Where applicable, the Certificate of accreditation under Manufacturer Accreditation Scheme (MAS) for PBU system; and • Where applicable, the dimension of building components and the type and extent of use of industry standard components.
Project Productivity Improvement Plan	Please refer to Appendix for details

4.2 Submission at Permit to commence structural works

The builder shall acknowledge the default Constructability Score in Form BPD_CCS01 and submit a proposal to demonstrate fulfilment of system formwork requirement. Form BPD_CCS01 can be downloaded from BCA's website at http://www1.bca.gov.sg/. The proposal shall include the following:

- The floor plan of every storey including roof, as well as the elevation plans and sectional plans which clearly mark out the extent of adoption of prefabricated systems and system formwork.

4.3 Departure and Deviation from Outcome-based Solutions

If there are any deviations to the outcome-based proposals (Deemed Acceptable Proposal or Project Productivity Improvement Plan) submitted at BP stage and/or Permit stage, the QPs and builder shall submit the revised proposals, revised default Buildable Design Score and revised default Constructability Score at least 3 working days before deviations are carried out at site. The revised proposal should demonstrate that the stipulated minimum requirements for the outcome-based solution can be met.

4.4 Submission at TOP/CSC stage

Upon project completion, the QPs and builder shall declare the default Buildable Design Score, Constructability Score and implemented proposals of the building works as completed (referred to as the record plans of Deemed Acceptable Proposal or Project Productivity Improvement Plan) using Form BPD_BS03 and Form BPD_CCS01. The submission is to be made before a temporary occupation permit or in a case where no such permit is earlier applied for, a certificate of statutory completion can be granted. Forms can be downloaded from BCA's website at http://www1.bca.gov.sg/.

BCA may conduct site checks during construction stage.

Appendix – Submission Requirements for Project Productivity Improvement Plan

(A) General

1. Overview of the proposed systems/ technologies/ designs
2. Construction cost
3. Construction time and floor cycle time achievable (comparison shall be made to conventional construction)
4. Productivity impact
5. Characteristics of the proposed systems/ technologies
6. Manufacturing process in factory
7. Method of assembly on site
8. Track record(s) of proposed systems/ technologies (both local and overseas, if any)

(B) Design

1. Construction material – include material type, grade and dimension
2. Structural design code and specification
3. Compliance with Building Control Act and Regulations and/or other international codes (show approvals from the Building Innovation Panel (BIP), overseas authorities, where relevant)
4. Compliance with other regulatory requirements (show approvals from the regulatory agencies such as LTA, NEA, MOM, PUB, SCDF)
5. Other details such as structural connections, test results (if any)
6. Architectural and structural plans to illustrate the following:
    - How the overall building design can support the implementation of the proposed systems/ technologies, including architectural finishes and MEP works
    - Extent of implementation of the proposed systems/technologies
    - Demonstrate how MEP works are planned, executed and integrated with all other trades upfront in design, prefabrication and installation.

(C) Construction

1. Scheduling, Monitoring and Productivity Tracking
    - Illustration of the use of effective project scheduling, monitoring and productivity tracking methodologies

2. Project Integration
    - Illustration of the adoption of virtual design and construction approach, integrated project delivery approach and/or other methodologies to achieve effective project integration and collaboration between different project team members

3. Innovations
    - Any other innovative proposals to support the construction management plan

(D) Impact on Productivity Improvement

- To provide comparison of productivity improvement between conventional construction method and the proposed innovation/ system/ technology/ design