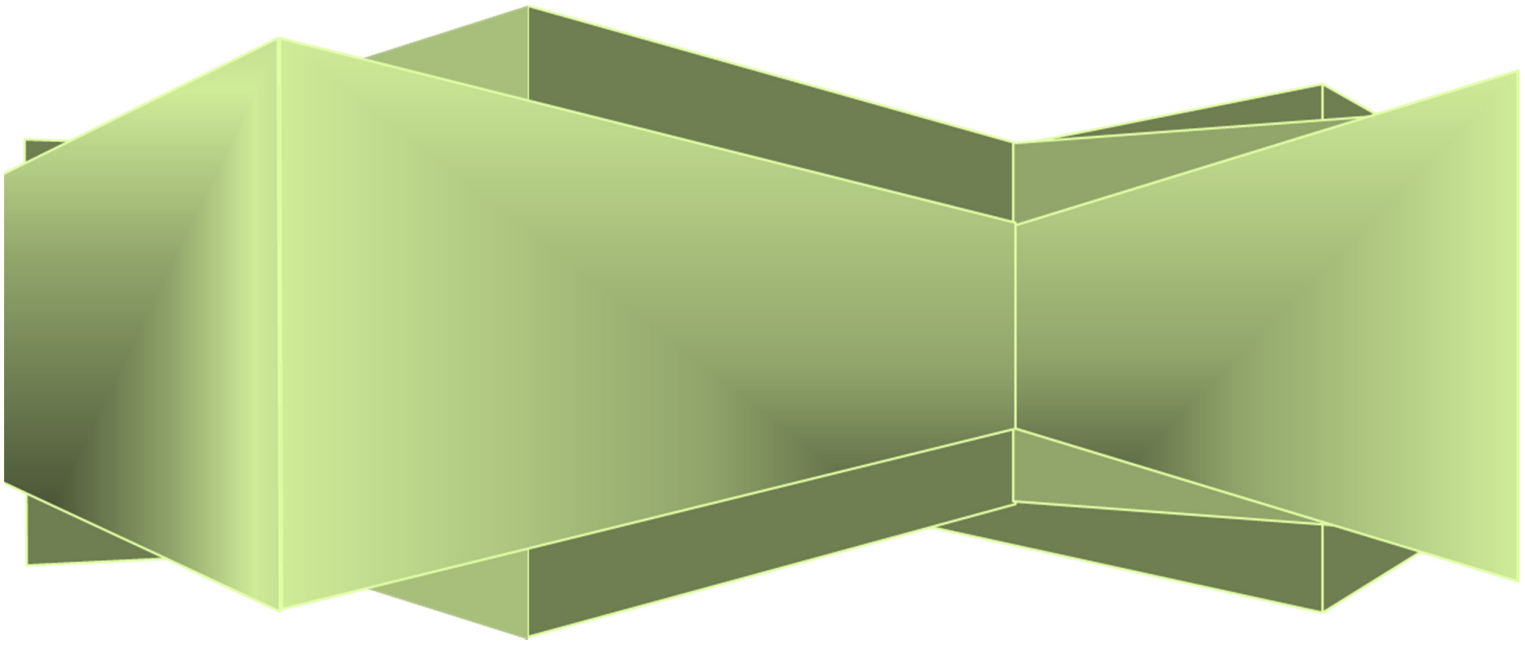
Building and Construction Authority

CODE OF PRACTICE ON

Buildability

2017 Edition



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CODE OF PRACTICE

ANNEX

Introduction

Since 2001, BCA had implemented the buildability legislation for all building projects to raise productivity in the built environment sector and reduce its reliance on foreign workers. The mandatory requirements for adoption of buildable designs had also been progressively raised over the years. The legislation has had the effect of changing some of the design practices in the industry, for example, the switch to more flat plate designs, dry walls, precast construction and prefabrication, and adoption of higher repetition of grids, floor-to-floor heights and more repeated component sizes.

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, especially in view of the more aggressive reductions in foreign worker supply, BCA raised the minimum standards for Buildable Design Score and Constructability Score further in 2013. At the same time, the buildable design requirements were tightened to propel the industry towards adopting a greater degree of standardisation in building components and design parameters.

Going forward, there is a need to lift productivity onto a higher plane by getting the industry to design and construct more buildable buildings and to exploit more labour-efficient technologies and productive methods of construction. Thus, in 2014 and 2015, besides further raising the minimum scores, BCA has mandated the adoption of key productivity components including industry-wide standard dimensions and building components for specific types of development. In addition, specific productive technologies have also been 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.

While the industry has made good progress over the years, there is a need to build on the momentum and continue to strive for higher productivity improvement. As part of the larger drive towards wider adoption of prefabrication technologies along the DfMA continuum, the buildability legislative framework has been enhanced further to raise construction productivity.

This Code sets out the requirements of minimum Buildable Design Score, minimum Constructability Score and their submission procedures. It also sets out the method of determining the Buildable Design Score and the Constructability Score, as well as the requirements for the specific productive technologies stipulated for GLS sites which need to be fulfilled. 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 and minimum Constructability Score 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:

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.
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).
Labour Saving Index (LSI)	A value given to a particular building system which reflects the relative difference in site labour productivity associated with the various structural and wall systems. In certain instances, the LSI could be further lowered to discourage the use of labour intensive elements or components. A LSI is also given for the use of prefabricated reinforcement/cages in cast in-situ components.
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.
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.

3.2.2 The developer shall engage the appropriate Qualified Persons (QPs) to carry out buildable design. The QP for Architectural Works and the QP for Structural Works shall be responsible for ensuring that the Buildable Design Score requirement is met. Where applicable, the QPs shall also be responsible for ensuring that the mandatory buildable systems and standard dimensions/components as set out in Annex A – Section 2 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 - Sections 3 to 6 are adopted and have met the minimum requirements. The QPs shall jointly declare the Buildable Design Score achieved. The QPs 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.

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
Residential (landed)	• Terrace house • Semi-detached house • Bungalow • Clustered housing

Table A Categories of Building *(continued)*

CATEGORIES	TYPES OF DEVELOPMENT
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 • Godown • Brewery • Cold storage building • Packaging and processing plant • Printing plant
School	• Primary school • Secondary school
Institutional and others	• Library • Hospital • Home for the aged • Childcare centre/Nursery • Research building • Educational facilities • Terminal building • Campus • Medical centre • Camp • Embassy • Museum • Crematorium and Columbarium • Club house

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

CATEGORIES	TYPES OF DEVELOPMENT
Institutional and others	• Cinema/Theatre • Sports/Recreational facilities • Public transport station • Sub-station

The above list shall not be exhaustive. The QP/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 three areas of scoring

The Buildable Design Score of a project is made up of 3 parts:

Part 1 - Structural System (maximum 45 points). Points are awarded for the use of various types of structural system and structural buildable design features.

Part 2 - Wall System (maximum 45 points). Points are awarded for the use of various types of wall system and architectural buildable design features.

Part 3 - Design for Manufacturing and Assembly (DfMA) technologies (maximum 20 points). Points are awarded for various technologies along the DfMA continuum and across the structural, architectural and mechanical, electrical & plumbing (MEP) disciplines. These include Prefabricated Prefinished Volumetric Construction (PPVC), mass engineered timber (MET), structural steel, prefabricated bathroom units (PBUs) and prefabricated MEP modules, integrated precast concrete components etc.

In addition to the above, points for standardisation of components and repetition of layouts/grids are incorporated under Part 1 and Part 2. Part 1 and Part 2 also include points given for the use of productive technologies and other buildable designs such as self-compacting concrete, simple design, dry construction, engineered timber flooring etc.

The maximum Buildable Design Score achievable for a project is capped at 110 points.

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 2,000 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 2,000 m^2 or more.

5.2.3 For building works with GFA equals to or greater than 2,000 m^2 but less than 5,000 m^2 and for which applications for planning permission were made before 1st January 2004, the minimum Buildable Design Score requirement shall not be applicable.

5.2.4 For buildings not listed in the First Schedule, the QP 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 1st May 2017, 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, school projects and institutional and other projects are tabulated in Table B and Table C 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. These minimum Buildable Design Scores shall also apply to any building works relating to any building on land sold under the Government Land Sales (GLS) Programme (including industrial GLS) on or after 1st May 2017.

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

Table B Minimum Buildable Design Score for Superstructure of All New Building Works

CATEGORY OF BUILDING WORK / DEVELOPMENT	MINIMUM BUILDABLE DESIGN SCORE FOR SUPERSTRUCTURE WORKS		
	2,000 m^2 ≤ GFA < 5,000 m^2	5,000 m^2 ≤ GFA < 25,000 m^2	GFA ≥ 25,000 m^2
Residential (landed)	73	78	81
Residential (non-landed)	80	85	88
Commercial	82	87	90
Industrial	82	87	90
School	77	82	85
Institutional and others#	73	79	82

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

 # MRT underground station projects are classified under this category and subjected to the corresponding minimum scores in Table B.

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

CATEGORY OF BUILDING WORK / DEVELOPMENT	MINIMUM BUILDABLE DESIGN SCORE FOR BASEMENT WORKS
	GFA ≥ 2,000 m^2
Residential (landed)	68
Residential (non-landed)	
Commercial	
Industrial	
School	
Institutional and others	

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

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

Table D Minimum Buildable Design Score for A&A Work

CATEGORY OF BUILDING WORK / DEVELOPMENT	MINIMUM BUILDABLE DESIGN SCORE
Residential (landed)	57
Residential (non-landed)	60
Commercial	62
Industrial	62
School	60
Institutional and others	60

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 E 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*
1st September 2013 – 31st October 2014	Code of Practice on Buildability *2013 edition*

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

Date of planning application	Code of Practice to be used
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*
On or after 1st May 2017	Code of Practice on Buildability *2017 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% residential (non-landed) and 30% commercial is computed as follows:

Table F 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
Residential (non-landed)	70% of GFA	70% of 85* = 59.50
Commercial	30% of GFA	30% of 87* = 26.10
The required minimum Buildable Design Score	100% of GFA	**86 (rounded to nearest integer)**

**based on 1st May 2017 minimum Buildable Design Scores for superstructure of new building works*

Table G 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
Residential (non-landed)	70% of GFA	70% of 88* = 61.60
Commercial	30% of GFA	30% of 90* = 27.00
The required minimum Buildable Design Score	100% of GFA	**89 (rounded to nearest integer)**

**based on 1st May 2017 minimum Buildable Design Scores for superstructure of new building works*

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 H 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 62 = 12.40
Work outside existing building	80% of GFA	80% of 87* = 69.60
The required minimum Buildable Design Score	100% of GFA	**82**

**based on 1st May 2017 minimum Buildable Design Scores for superstructure of new building works*

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 at the following stages:

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

6.1 Submission at BP Stage

The QP shall indicate in Form BPD_BP03 (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 and the QP for Structural Works and the detailed computation of the Buildable Design Scores shall be attached. Forms BPD_BP03 and BPD_BS01 can be downloaded from BCA's website at http://www.bca.gov.sg/.

In addition to the above, the QPs must submit a Buildability Detailed Design and Implementation Plan jointly declared by the QP for Architectural Works and the QP for Structural 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 and wall length for every structural system and wall system of that storey, as well as the Design for Manufacturing and Assembly (DfMA) technologies and any buildable feature adopted;

- the elevation plans and sectional plans which clearly mark out the types of structural system, wall system, DfMA technologies 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 precast components, the connection and details of precast components, the details of prefabricated reinforcement and the locations as well as the details of all DfMA technologies 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 (BEV/A1) (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 super-structural stage using Form BCA-BE-BS02 (BEV/A1_BS02). The Structural Buildable Design Scores are to be jointly declared by the QP for Architectural Works and the QP for Structural Works. Forms BCA-BE-STAPPV01 (BEV/A1) and BCA-BE-BS02 (BEV/A1_BS02) can be downloaded from BCA's website at http://www.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 and the QP for Structural 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 as well as the DfMA technologies and any buildable feature adopted;

- the elevation plans and sectional plans which clearly mark out the types of structural system, DfMA technologies 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 precast components, the connection and details of precast components, the details of prefabricated reinforcement as well as the locations and details of all DfMA technologies 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, wall 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 and the QP for Structural Works are required to submit an amended Buildability Detailed Design and Implementation Plan for approval. The QPs 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 and the QP for Structural Works.

6.4 Submission at TOP/CSC stage

6.4.1 Upon project completion, the QP for Architectural Works and the QP for Structural 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 and the QP for Structural 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 http://www.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, school projects and institutional and other projects comprising buildings of more than 6 storeys high which are submitted for planning permission on or after 1st May 2017 are tabulated in Table I. These minimum Constructability Scores shall also apply to any building works relating to any building on land sold under the Government Land Sales (GLS) Programme (including Industrial GLS) on or after 1st May 2017.

7.3.2 For developments comprising buildings of 6 storeys and below which are submitted for planning permission on or after 1st May 2017, the minimum Constructability Scores are tabulated in Table J. These minimum Constructability Scores shall also apply to any building works relating to any building on land sold under the GLS/Industrial GLS Programme on or after 1st May 2017.

7.3.3 Different minimum Constructability Score requirements are given for 5,000 m^2 ≤ GFA < 25,000 m^2 and GFA ≥ 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 I and Table J.

Table I Minimum Constructability Score for All Building Works comprising Buildings more than 6 Storeys

CATEGORY OF BUILDING WORK / DEVELOPMENT	MINIMUM CONSTRUCTABILITY SCORE	
	5,000 m^2 ≤ GFA < 25,000 m^2	GFA ≥ 25,000 m^2
Residential (landed)	50 (min 35 points from Structural System)	60 (min 45 points from Structural System)
Residential (non-landed)		
Commercial		
Industrial		
School		
Institutional and others		

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

Table J 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
Residential (landed)	50 (min 32 points from Structural System)	60 (min 42 points from Structural System)
Residential (non-landed)		
Commercial		
Industrial		
School		
Institutional and others		

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

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 K 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*
On or after 1st May 2017	Code of Practice on Buildability *2017 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.

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 http://www.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 evidences 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

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. Such Construction Productivity Data shall be submitted to BCA on a monthly basis which would be used to assess the productivity level of the building works. The Construction Productivity Data shall include the manpower usage, construction output and documentation relating to the construction of the building works.

First Schedule

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

The types of development which are not subjected 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. A flat plate system, for example, eases formwork construction as well as reinforcement work considerably. Use of DfMA technologies or prefabricated components 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 bathroom units 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 and the major architectural components such as external and internal wall systems, doors and windows.

Points are awarded based on the types of structural and architectural 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, wall systems, DfMA technologies and buildable features. The maximum Buildable Design Score achievable for a project is 110 points.

The allocation of points to structural systems, wall systems, DfMA technologies and buildable features is based on manpower consumption.

1.6 Rationale on Derivation of Labour Saving Indices

One of the important factors in the appraisal system is the Labour Saving Index (LSI). A Labour Saving Index is given to each building system and the use of prefabricated reinforcement/cages in cast in-situ components. The building systems and their corresponding indices will be updated regularly to reflect the changes in technology.

Projects were identified for each type of building system to undergo studies. Site productivity, measured in square metres per manday, relating to each building system was analysed. Based on the relative difference in labour productivity, the Labour Saving Index for each building system was derived. In certain instances, the Labour Saving Indices could be further lowered to discourage the use of labour intensive elements or components.

A high index indicates that the design is more buildable and fewer site workers are needed.

1.7 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.

1.8 Updates

This Code of Practice on Buildability, 2017 Edition, has included a number of updates.

1.8.1 Enhanced Buildable Design Appraisal System (BDAS) incorporating more Design for Manufacturing and Assembly (DfMA) Technologies

The key changes are listed below:

(a) A new Table comprising a continuum of DfMA technologies from prefabricated components to fully integrated assemblies across the structural, architectural, as well as Mechanical, Electrical and Plumbing (MEP) disciplines is added. The total points allocated to this DfMA Table is 20 points.

(b) The Buildable Design Features under Table 3 of the BDAS in the previous Code of Practice on Buildability, 2015 edition have been incorporated under either Table 1 on Structural System or Table 2 on Wall System, where appropriate. The total points for Structural System and Wall System remains at 45 points each.

(c) The maximum Buildable Design Score achievable for a building design under the 3 main parts of Structural System, Wall System and DfMA Technologies is 110 points instead of 100 points.

1.8.2 Separate Minimum Buildable Design Scores (B-Scores) for Basement Works and Superstructure Works

The key changes are listed below:

(a) A new minimum B-Score of 68 points for basement works has been introduced and shall apply to all categories of development with basement.

(b) The minimum B-Score for superstructure works are the same as those stated in the Code of Practice on Buildability, 2015 edition.

(c) For projects with basement works, they are now required to comply with the minimum B-Scores for both superstructure works and basement works.

1.8.3 Higher Minimum Level of Use of Prefabrication Systems for Industrial Sites Sold under the Industrial Government Land Sales (IGLS) Programme

(a) The minimum levels of prefabrication for structural system and wall system have been raised.

1.8.4 Mandatory Adoption of Structural Steel Construction for Selected Sites Sold under the Government Land Sales (GLS) Programme

(a) Under land sales conditions, the adoption of a minimum level of structural steel construction is mandated for office buildings built on selected land parcels sold under the GLS Programme.

The requirements and details have been spelt out in the relevant section.

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 three main parts:

(a) the Structural System;

(b) the Wall System; and

(c) Design for Manufacturing and Assembly (DfMA) Technologies.

Buildable Design Score of the Structural System

A designer could use different structural systems for different parts of the building so as to achieve the best practical design. The Buildable Design Score for a particular structural system is the product of the percentage area covered by the structural system and its corresponding Labour Saving Index available in Table 1. For the use of welded mesh for cast-in-situ concrete floor which is mandatory for all types of development and other prefabricated reinforcement such as column cages, the Buildable Design Score is the product of the percentage of coverage of use and the corresponding Labour Saving Index as shown in Table 1. The Buildable Design Scores for the different structural systems adopted and the use of prefabricated reinforcement are then summed up and multiplied by the weight factor to arrive at the Buildable Design Score of the various structural systems and prefabricated reinforcement. The Buildable Design Score achievable for structural systems and prefabricated reinforcement is 45 points.

In this section, points are also given for the use of various structural buildable design features such as precast household shelters mandated for residential non-landed projects, precast meter chambers etc. Other items that are recognized with points include standardization of columns and beams, vertical repetition of structural floor layout, use of high strength concrete, self-compacting concrete and diaphragm wall. The maximum points achievable for the adoption of structural buildable features, standardization of components, repetition of layout and use of productive technologies is 5 points.

Overall, the maximum Buildable Design Score achievable under this section on structural systems is 45 points.

Buildable Design Score of the Wall System

The Buildable Design Score for a particular wall system is computed by multiplying the percentage wall length covered by the wall system and its corresponding Labour Saving Index available in Table 2. The Buildable Design Scores for the different wall systems adopted are then summed up and multiplied by the weight factor to arrive at the Buildable Design Score of the various wall systems.

In this section, the use of drywall for all internal dry areas (exclude party wall/toilet wall/kitchen wall) is mandatory for all residential non-landed projects.

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 section, points are also given for the use of various architectural buildable design features, standardized components/design parameters, repetition of grids and dry construction. Examples include standard floor heights, door structural openings, precast refuse chutes and precast staircases which are mandated for use in specific types of projects, other standard components at both project level and industry level, engineered timber flooring, drywall for party wall and wet areas etc. The maximum points achievable for the adoption of these architectural buildable features and designs is 5 points.

Overall, the maximum Buildable Design Score achievable under this section on wall systems is 45 points.

Buildable Design Score of DfMA Technologies

In this section, points are given for various technologies along the DfMA continuum and across the structural, architectural as well as mechanical, electrical & plumbing (MEP) disciplines. The DfMA technologies are categorized into different classes ranging from Prefabricated Components, Advanced Prefabricated Systems, Fully Integrated Sub-assemblies to Fully Integrated Systems to differentiate the potential manpower savings expected from their adoption. The use of these DfMA technologies will be awarded with points directly.

Examples of DfMA technologies under the class of Prefabricated Components include MEP systems such as flexible sprinkler dropper and flexible water pipes, use of mechanical connections for precast components, prefabricated wall with onsite dry applied finishes and integrated precast components. Under the class of Advanced Prefabricated Systems, the DfMA technologies include structural steel, prefabricated MEP modules e.g. for pipes and unitized curtain wall. As for labour saving technologies such as mass engineered timber and prefabricated bathroom units (PBUs), these are classified under Fully Integrated Sub-assemblies while Prefabricated Prefinished Volumetric Construction (PPVC) is a Fully Integrated System.

The maximum Buildable Design Score that can be achieved in this section is 20 points.

Overall, the maximum Buildable Design Score achievable under the 3 main parts of Structural System, Wall System and DfMA Technologies is 110 points.

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 Wall System + Buildable Design Score of DfMA Technologies
B-Score	=	$\{45[\sum(A_s x S_s)] + \text{Structural Buildable Features Points}\}^{\#} + \{40[\sum(L_w x S_w)] + C + \text{Architectural Buildable Features Points}\}^{\#} + N^{@}$
where A_s	=	A_{sa} / A_{st}
L_w	=	L_{wa} / L_{wt}
A_s	=	Percentage of total floor area using a particular structural system
A_{st}	=	Total floor area which includes roof (projected area) and basement area
A_{sa}	=	Floor area using a particular structural system
L_w	=	Percentage of total external & internal wall length using a particular wall system
L_{wt}	=	Total external & internal wall length, excluding the length of external basement wall for earth retaining purpose.
L_{wa}	=	External & internal wall length using a particular wall system
S_s	=	Labour Saving Index for structural system (Table 1)
Structural Buildable Features Points	=	Points for the use of buildable designs/features such as standard columns and beams, vertical repetition of layout, prefabricated MEP risers, high strength concrete, self-compacting concrete and diaphragm wall (Table 1)
S_w	=	Labour Saving Index for external & internal wall system (Table 2)
C	=	Points for simple designs (Table 2)
Architectural Buildable Features Points	=	Points for the use of buildable designs/features such as standard components/design parameters at both project and industry level (including mandatory items for specific development types), drywall for party wall/wet areas and engineered timber flooring (Table 2)
N	=	Buildable Design Score of DfMA Technologies (Table 3)

 # capped at 45 points

@ capped at 20 points

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,

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

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: $45[\sum(A_s x S_s)]$ + Structural Buildable Features Points

A_s : The extent to which a particular structural system or prefabricated reinforcement is used. This is expressed as a percentage of the total floor area of the building in the case of structural system and the extent of coverage of use in each cast in-situ component in the case of prefabricated reinforcement.

S_s : A Labour Saving Index for the particular structural system and prefabricated reinforcement. The labour saving indices for the various structural systems and prefabricated reinforcement are given in Table 1.

Structural Buildable Features Points: Various structural buildable features, standardization of components, repetition of layout and use of productive technologies are given points as shown in Table 1. The maximum points given is capped at 5 points.

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 the structural system inclusive of structural buildable features is 45 points

(b) Buildable Design Score of Wall System

The score for the wall system is based on:

Method for computation : $40[\sum(L_w x S_w)]$ + C + Architectural Buildable Features Points

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

S_w : A Labour Saving Index for the particular external or internal wall system. The labour saving indices for the various wall systems are given in Table 2.

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 2.

Architectural Buildable Features Points:	Various architectural buildable designs/features such as standard components/design parameters at both project and industry level (including mandatory items for specific development types), drywall for party wall/wet areas and engineered timber flooring are given points as shown in Table 2. The maximum points given is capped at 5 points.

All wall 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 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 system inclusive of architectural buildable features is 45 points.

(c) Buildable Design Score of DfMA Technologies, N value

This section covers the various technologies along the DfMA continuum and across the structural, architectural as well as mechanical, electrical & plumbing (MEP) disciplines. Points are given for each technology adopted and these are summed up to give the score, up to a maximum of 20 points. The points of various technologies are given in Table 3.

The maximum overall Buildable Design Score is capped at 110 points.

Table 1 Structural Systems – S_s Value

STRUCTURAL SYSTEM	DESCRIPTION	LABOUR SAVING INDEX S_s
Precast Concrete System	Full precast	1.00
	Precast column/wall(2) with flat plate and perimeter beams (beam depth ≤ 600 mm)	0.90
	Precast column/wall(2) with flat plate and perimeter beams (beam depth > 600 mm)	0.80
	Precast column/wall(2) with flat slab and perimeter beams (beam depth ≤ 600 mm)	0.85
	Precast column/wall(2) with flat slab and perimeter beams (beam depth > 600 mm)	0.75
	Precast beam and precast slab	0.90
	Precast beam and precast column/wall(2)	0.90
	Precast column/wall(2) and precast slab	0.90
	Precast slab only	0.70
	Precast column/wall only(2)	0.70
Structural Steel System *(applicable only if steel decking or precast slab is adopted)*(1)	Steel beam and steel column *(without concrete encasement)*	1.00
	Steel beam and steel column *(with concrete encasement)*	0.95
Cast In-situ System	Flat plate with perimeter beams (beam depth ≤ 600 mm)	0.85
	Flat plate with perimeter beams (beam depth > 600 mm)	0.75
	Flat slab with perimeter beams (beam depth ≤ 600 mm)	0.80
	Flat slab with perimeter beams (beam depth > 600 mm)	0.70
	One-directional beam	0.70
	Two-directional beam	0.45
Roof System (non-RC)	Integrated metal roof on steel truss	1.00
	Metal roof on steel truss or timber truss	0.95
	Tiled roof on steel beam or precast concrete beam or timber beam	0.75
	Metal roof on cast in-situ beam	0.60
	Tiled roof with cast in-situ beam	0.55

NOTE:

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

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

* An index of 0.05 each would be given if prefabricated reinforcement/cage/continuous stirrup is used in cast in-situ slab, wall, beam and column.

* Indices for other 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.

Table 1 Mandatory Items

	DESCRIPTION	LABOUR SAVING INDEX Ss
1	Use of welded mesh for cast-in-situ concrete floor (≥ 65%) *(Mandatory for all projects)*(3)	0.05

	DESCRIPTION	UNIT OF COVERAGE	PERCENTAGE OF COVERAGE	
			≥ 65% TO < 80%	≥ 80%
2	Precast household shelters *(Mandatory for residential non-landed projects)*(4)	no.	1.00	2.00

NOTE:

(3) 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.

(4) For designs of residential non-landed projects that incorporate household shelters, it is mandatory for these household shelters to be precast.

Table 1 Standardisation and Repetition

	DESCRIPTION	MODULE	UNIT OF COVERAGE	PERCENTAGE OF COVERAGE(5)	
				≥ 70% TO < 90%	≥ 90%
1	Columns (3 most common sizes)	0.5M(6)	no.	1.50	2.00
2	Beams (3 most common sizes)	0.5M(6)	no.	1.50	2.00
3(a)	Vertical repetition of structural floor layout (For blocks more than 6 storey) *The repetition may omit bottom floor, top floor and above.*		area	1.50	2.00
3(b)	Vertical repetition of structural floor layout (For blocks up to 6 storey) *The repetition may omit bottom floor, top floor and above. Only applicable if there are at least 2 floors remaining after the floor omission.*		area	0.75	1.00

NOTE:

(5) Percentage of coverage is to be based on total floor area or on total number of columns or beams.

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

Table 1 Other Structural Buildable Features

DESCRIPTION		MODULE	UNIT OF COVERAGE	PERCENTAGE OF COVERAGE[7]	
				≥ 70% TO < 90%	≥ 90%
1	Precast meter chambers *(applicable to residential landed projects only)*		no.	0.50	1.00
2	Prefabricated MEP risers		no.	0.50	1.00
3	Single floor level without drops/kerbs within apartment unit *(e.g. at kitchen, toilets)*		no.	1.00	2.00

DESCRIPTION		DIRECT POINTS
4	High strength concrete (≥ Grade 70, at least 5%)[8]	1.00
5	Self-compacting concrete (≥ 30%)[9]	2.00
6	Diaphragm wall (≥ 65% length of basement permanent retaining wall) [10]	2.00

NOTE:

(7) Percentage of coverage is to be based on total number of components.
(8) High strength concrete of at least Grade 70 must be used for at least 5% of the total concrete volume.
(9) Self-compacting concrete must be used for at least 30% of the total concrete volume.
(10) Diaphragm wall must be adopted for at least 65% of the permanent retaining wall at basement.

EXPLANATORY NOTES TO TABLE 1

(a) Table 1 has been arranged into 4 main systems of precast concrete system, structural steel system, cast in-situ system and roof system with their respective labour saving indices. In the event when a structural system used for a project is not stated in Table 1, the Labour Saving Index shall be decided by BCA.

(b) For precast concrete system, the labour saving indices 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) The index for concrete roof depends on the type of structural system used and follows the respective index given under cast In-situ system or precast concrete system.

(e) The integrated metal roof refers to prefabricated roofing system complete with insulation and can be installed as an entire roof section.

(f) Additional points in the form of labour saving index of 0.05 each would be awarded for the use of prefabricated reinforcement/cages in cast in-situ floor, beam, column and wall.

In the case of prefabricated reinforcement for cast in-situ floor, it is mandatory that at least 65% of the floor area must use welded mesh.

The percentage of coverage for the use of prefabricated reinforcement/cages is to be based on the total cast in-situ floor area or on the total number of cast in-situ columns or total number of cast in-situ beams or total number of cast in-situ walls.

The use of prefabricated reinforcement/cages must be indicated on plans.

(g) For the Section on Standardisation and Repetition, the criteria of minimum module must be met before points are given. M denotes 100mm. 0.5M implies that sizes must be in multiples of 50mm.

(e) The unit of measurement for mandatory item on precast household shelter, standard building components, repetition of floor layout and buildable features is in number or area. This is specified in the column entitled “Unit of Coverage.”

(f) The percentage of coverage of each type of standard building component, repetition of floor layout and other structural buildable feature is classified into 2 categories:

(i) $\geq 70\%$ to $< 90\%$

(ii) $\geq 90\%$

In the case of mandatory item on precast household shelter, the percentage of coverage is classified into the following categories:

(i) ≥ 65% to < 80%

(ii) ≥ 80%

(g) The maximum points for structural buildable features including mandatory items, standardisation of components and repetition of floor layout achievable under Table 1 is capped at 5 points.

Table 2 Wall Systems – S_w Value

WALL SYSTEM	DESCRIPTION	LABOUR SAVING INDEX S_w
Drywall ***(Mandatory Component)***	Dry partition wall for all internal dry areas (exclude party wall/toilet wall/kitchen wall) (*applicable to residential non-landed projects only*)	1.00
Curtain wall / full height glass partition / dry partition wall / prefabricated railing	Curtain wall / Full height glass partition	1.00
	Prefabricated railing	1.00
	Dry partition wall	1.00
	Dry partition wall with tile / stone finishes	0.90
Precast Concrete Wall(2)	Off-form precast concrete external walls and columns(4)	1.00
	Precast concrete wall with skim coat	0.90(1)
	Precast concrete wall with plastering, tile / stone finishes	0.60
Lightweight Concrete Panel(3)	Lightweight concrete panel with skim coat	0.85(1)
	Lightweight concrete panel with plastering, tile / stone finishes	0.55
Cast In-situ RC Wall	Off-form cast in-situ RC external walls and columns(4)	0.95
	Cast in-situ RC wall with skim coat	0.80(1)
	Cast in-situ RC wall with plastering, tile / stone finishes	0.50
Precision Blockwall	Precision blockwall with skim coat	0.30(1)
	Precision blockwall with plastering, tile / stone finishes	0.10
Brickwall / Blockwall	Brickwall / blockwall with or without plastering (*to include the length if used*)	Refer to Separate Section on Demerit Points(5)

NOTE:

(1) These indices also apply to the respective walls with no finishes or finishes done off-site.

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

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

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

(5) The use of brickwall/blockwall, once used, must be indicated and its wall length computed under the wall system. Demerit points for the use of brickwall/blockwall will be computed under a separate section on Demerit Points.

* Indices for other systems not shown in this table shall be determined by BCA on a case-by-case basis

DESCRIPTION	Direct Points
Design without high voids	See Table 2A
Design without complex form	See Table 2B

Table 2A: Points for designs without high voids

Case	Percentage of high void = $\frac{\text{Total void height (only for heights > 9m)}}{\text{Total building height (m)}}$	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:
* High voids refer to heights that are more than 9m.
* A design that does not have any void height greater than 9m throughout its building height will get a maximum of 2 points.

Table 2B: Points for designs without complex form

Scenario	1	2	3	4	5	6
Maximum Offset	Nil	0 m to < 1 m	1 m to < 2 m	2 m to < 3 m	3 m to < 4 m	≥ 4 m
% 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:
* Complex forms refer to building façades that are tilted, tapered, twisted or of free form.
* A design that does not have complex form will get a maximum of 3 points.

Table 2 Mandatory Items

DESCRIPTION		MODULE	UNIT OF COVERAGE	PERCENTAGE OF COVERAGE[6]	
				≥ 70% TO < 90%	≥ 90%
1(a)	Typical storeys standardised to either 2.8m, 2.975m, 3.15m, 3.3m, 3.5m or 3.6m height (*applicable to residential non-landed projects only*)		no.		2.00
1(b)	Typical storeys standardised to either 4.025m, 4.2m, 4.375m, 4.5m, 4.55m, 4.725m, 4.8m or 4.9m height (*applicable to office projects only*)		no.		2.00
1(c)	Typical storeys standardised to either 3.15m, 3.3m, 3.325m, 3.45m, 3.5m or 3.6m height *(applicable to hotel projects only*)		no.		2.00
2	Standard door structural openings (width) (3 most common sizes) *(see Table 2C)* (*applicable to residential non-landed projects only*)		no.	0.50	1.50
3	Standard precast refuse chutes *(see Table 2D)* (*applicable to residential non-landed projects only*)		no.	0.50	1.00
4(a)	Standard precast staircase of riser height of 150mm or 175mm & tread width of 275mm or 300mm for typical storeys (*applicable to all projects except industrial projects*)		no.	1.00	2.00
4(b)	Standard precast staircase of riser height of 150mm or 175mm & tread width of 250mm, 275mm or 300mm for typical storeys (*applicable to industrial projects only*)		no.	1.00	2.00

NOTE:

[6] Percentage of coverage is to be based on total number of components such as door openings, precast refuse chutes etc.

Table 2 Standardisation and Repetition

DESCRIPTION		MODULE	UNIT OF COVERAGE	PERCENTAGE OF COVERAGE[6]	
				≥ 70% TO < 90%	≥ 90%
1	Windows (3 most common sizes)[7]	1M/1M[8]	no.	0.75	1.00
2	Door structural openings (width) (3 most common sizes)	0.5M	no.	0.75	1.00
3(a)	Repetition of floor-to-floor height (For blocks more than 6 storey) *The repetition may omit bottom floor, top floor and above.*	0.5M	no.	1.50	2.00
3(b)	Repetition of floor-to-floor height (For blocks up to 6 storey) *The repetition may omit bottom floor, top floor and above. Only applicable if there are at least 2 floor heights remaining after the floor omission.*	0.5M	no.	0.75	1.00
4	Repetition of horizontal grids	6M	no.	1.50	2.00

NOTE:

[7] Sizes based on dimensions of frames.

[8] 1M for width and 1M for height (1M = 100 mm).

Table 2 Other Architectural Buildable Features

	DESCRIPTION	MODULE	UNIT OF COVERAGE	PERCENTAGE OF COVERAGE[9]	
				≥ 65% TO < 80%	≥ 80%
1	Typical storeys standardised to either 2.8m, 2.975m, 3.15m, 3.3m, 3.325m, 3.45m, 3.5m, 3.6m, 4.025m, 4.2m, 4.375m, 4.5m, 4.55m, 4.725m, 4.8m or 4.9m height and with precast staircase of riser height of 150mm or 175mm & tread width of 250mm or 275mm		no.	1.00	2.00
2	Industry standard door structural openings *(see Table 2C)*		no.	0.50	1.50
3	Industry standard precast refuse chutes *(see Table 2D)*		no.	0.50	1.00
4	Industry standard precast household shelters (3 most common sizes) *(see Table 2E)*		no.	1.00	2.00
5	Industry standard prefabricated bathroom/toilet units[10] [applicable to item A2.8 (a) or A2.8 (b)] (3 most common sizes) *(see Table 2F)*		no.	1.00	2.00
6	Drywall for party wall *(applicable for residential projects only)*		no.	2.00	4.00
7	Drywall for wet areas (kitchens and toilets) *(applicable to residential projects only)*		no.	1.50	3.00
8	Engineered timber flooring, carpet, vinyl, raised floor and engineered stone flooring finishes		area		0.50
9	Power float concrete floor		area		1.00

NOTE:

[9] Percentage of coverage is to be based on total area or on total number of components.

Table 2 Demerit Points

	DEMERIT POINTS	MODULE	UNIT OF COVERAGE	PERCENTAGE OF COVERAGE	POINT DEDUCTION
1	Non-functional void on slab[10]				-1.00
2	Cast in-situ floor with transfer beam[11]		no.	< 30%	-1.00
				≥ 30% to < 60%	-1.50
				≥ 60%	-2.00
3	Cast in-situ floor with cantilever transfer beam[11]		no.	< 30%	-2.00
				≥ 30% to < 60%	-2.50
				≥ 60%	-3.00
4	Inclined columns[12]		no.	< 30%	-1.00
				≥ 30%	-1.50
5	Brickwall / Blockwall[13]		length	< 20%	-2.00
				≥ 20%	-3.00

NOTE:

[10] This refers to void on slab that does not serve any functional requirement and is enclosed by walls. The 1.00 point deduction applies even if there is only one such void within a block.

[11] 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 on that floor. Point deduction applies to every floor with transfer beam/cantilever transfer beam according to the percentage of coverage. This requirement does not apply to cast in-situ floor with transfer beam designed for ramp access.

[12] 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 every floor with inclined columns according to the percentage of coverage.

[13] The percentage of coverage of use of brickwall / blockwall is determined from its wall length as tabulated under the wall system in Table 2.

EXPLANATORY NOTES TO TABLE 2

(a) Table 2 has been arranged into the various wall systems with their respective labour saving indices. Mandatory wall system(s) for specific types of developments are also included. In the event when a wall system used for a project is not stated in Table 2, the Labour Saving Index shall be decided by BCA.

(b) 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.

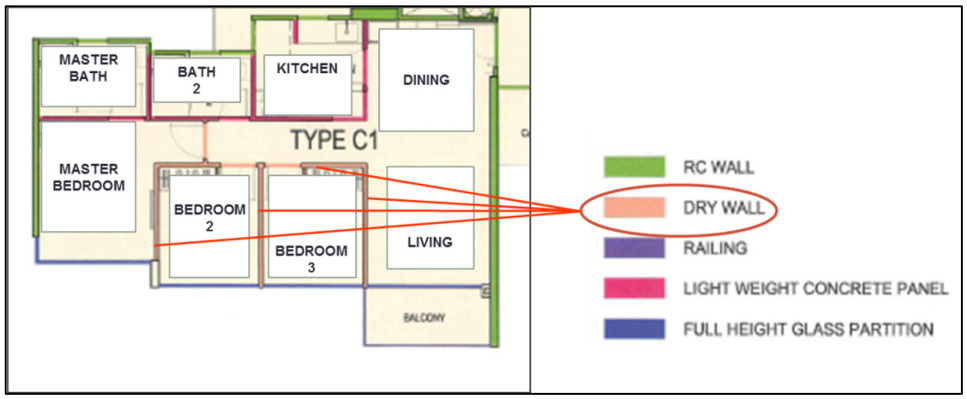


Figure 1 – Example of a layout showing the mandatory use of drywall for all internal dry areas.

(c) The Labour Saving Index for full height windows and doors is 1.00.

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

(e) 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 2A.

(f) 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, direct points are awarded based on the lower of the points given for maximum offset and percentage of offset floors as shown in Table 2B.

(g) For the Section on Mandatory Items, these are applicable to specific types of projects as stated. Points claimed for these mandatory items cannot be duplicated for claiming of points under the Sections on Standardisation and Repetition as well as Other Architectural Buildable Features.

(h) For the Section on Standardisation and Repetition, the criteria of minimum module must be met before points are given. M denotes 100mm. 0.5M implies that sizes must be in multiples of 50mm. 1M implies that sizes must be in multiples of 100mm. For repetition of floor-to-floor height, 0.5M implies that the floor-to-floor height must be in multiples of 50mm. For repetition of horizontal grids, 6M implies that spacing between grids must be in multiples of 600mm.

(e) For industry standardisation of building components/design parameters under the Section on Other Architectural Buildable Features, please refer to Table 2C, Table 2D, Table 2E and Table 2F.

(f) The unit of measurement for mandatory items, standard building components, repetition of design parameters/grids and buildable features is in number or area. This is specified in the column entitled "Unit of Coverage."

(g) The percentage of coverage of each type of mandatory item, standard building component, repetition of design parameter/grid is classified into 2 categories:

(i) ≥ 70% to < 90%

(ii) ≥ 90%

In the case of other architectural buildable features, the percentage of coverage is classified into the following categories:

(i) ≥ 65% to < 80%

(ii) ≥ 80%

(h) The maximum points for architectural buildable features including mandatory items, standardisation of building components/design parameters under Table 2 is capped at 5 points.

Table 2C: Industry Standard Door Structural Openings

S/No	Door Structural Opening (Width) (mm)
1	900
2	1000
3	1100
4	1200
5	1250
6	1500
7	2000

NOTE:

1. This item is a mandatory component to be met by all residential non-landed projects. These projects are required to adopt the above standard door structural opening sizes (up to 3 sizes) as shown in Table 2 – Mandatory Items.
2. 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 2 – Other Architectural Buildable Features.

Table 2D: Industry Standard Precast Refuse Chutes

S/No	Outer Dimensions (m)	Inner Dimensions (m)	Chamfer Radius (mm)
1	1.0 x 1.0	0.8 x 0.8	150
2	0.9 x 0.9	0.7 diameter	N.A.
3	0.8 x 0.8	0.5 or 0.6 diameter	N.A.

NOTE:

1. This item is a mandatory component to be met by all residential non-landed projects. These projects are required to adopt one of the above standard precast refuse chute sizes as shown in Table 2 – Mandatory Items.
2. For other types of projects, points are awarded to a project if one of the above standard precast refuse chute sizes is adopted and meeting the required percentage of coverage as shown in Table 2 – Other Architectural Buildable Features.

Table 2E: Industry Standard Precast Household Shelters

GFA of Dwelling Unit (m^2)	Minimum Inner Floor Area (m^2)	Size (m/m)	Wall Thickness (mm)
45 < GFA ≤ 75	2.2	1.2 x 1.9, 1.3 x 1.7, 1.45 x 1.6	250 or 300
75 < GFA ≤ 140	2.8	1.2 x 2.4, 1.25 x 2.3, 1.3 x 2.2, 1.35 x 2.1, 1.45 x 1.95	250 or 300
GFA > 140	3.4	1.5 x 2.4, 1.6 x 2.2	250 or 300

NOTE:
Points are awarded to a project only if the above sizes of standard precast household shelter (up to 3 sizes) are adopted and meeting the required percentage of coverage as shown in Table 2 – Other Architectural Buildable Features.

Table 2F: Industry Standard Prefabricated Bathroom Units

Internal Dimensions (m)		
Master Bath	**Common Bath**	**Maid / Yard Bath**
1.8 x 2.6	1.5 x 2.5	0.8 x 1.5
2.0 x 2.4	1.7 x 1.8	1.2 x 1.5
2.0 x 2.6	1.7 x 2.0	1.2 x 1.6
2.0 x 3.4	1.7 x 2.2	1.2 x 2.2
2.2 x 2.8	1.8 x 2.8	
	1.9 x 1.9	
	2.0 x 2.0	

NOTE:
1. The sizes are based on internal dimensions, i.e. exclude the wall thickness of the prefabricated bathroom unit as shown in Figure 2 below.
2. Points are awarded to a project only if
   i. the above sizes of standard prefabricated bathroom units (up to 3 sizes) are adopted and meeting the required percentage of coverage as shown in Table 2 – Other Architectural Buildable Features, and
   ii. the location of the services shaft is 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.

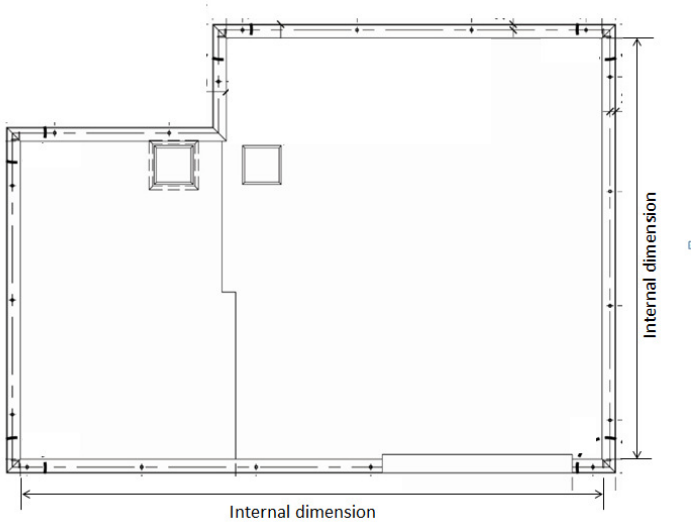


Figure 2 – Plan of a prefabricated bathroom unit and its internal dimensions

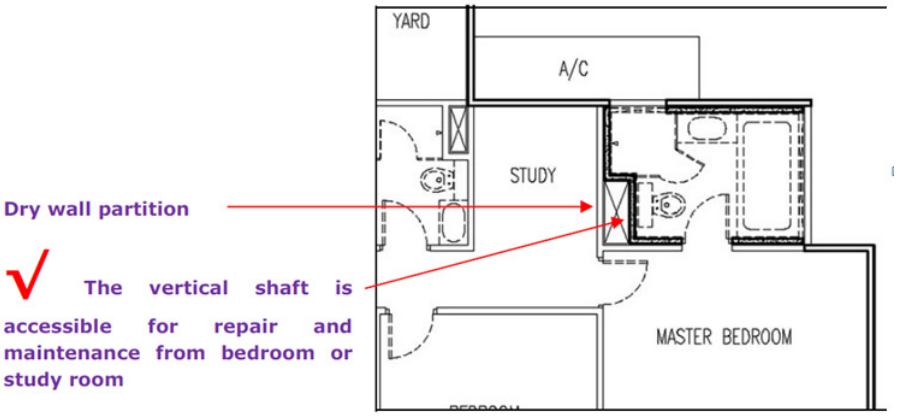


Figure 3 – Example of a layout of a prefabricated bathroom unit with a services shaft that is accessible for future repairs and maintenance

Table 3 Design for Manufacturing and Assembly Technologies (DfMA) – N Value

DESIGN FOR MANUFACTURING AND ASSESMBLY TECHNOLOGIES (DFMA)			UNIT OF COVERAGE	N VALUE	
				PERCENTAGE OF COVERAGE[1]	
				≥ 65% TO < 80%	≥ 80%
A1. First Class					
Fully Integrated System					
A1.1	Prefabricated Prefinished Volumetric Construction (PPVC)[2] *{The PPVC system has to be accepted by the Building Innovation Panel (BIP) and accredited under the PPVC Manufacturer Accreditation Scheme}*		area	8.00	10.00
A1.2	Prefabricated Prefinished Volumetric Construction (PPVC) meeting requirements stipulated under Sections 5.1 and 5.2		area	6.00	7.00
A2. 2nd Class (Upper)					
Fully Integrated Sub-assemblies					
A2.1	Mass Engineered Timber (e.g. Cross Laminated Timber, CLT)		area[3]	6.00	7.00
A2.2	Prefabricated Volumetric Construction (PVC)		area	5.00	6.00
A2.3	Structural steel with innovative connections[4]		area	5.00	6.00
A2.4	Steel-Mechanical, Electrical and Plumbing (MEP) floor system		area	5.00	6.00
A2.5	Prefinished wall with MEP services		length	1.00	2.00
A2.6	Prefinished ceiling with MEP services		area	1.00	2.00
A2.7	Prefabricated MEP modules integrated with work platform/catwalk		no.	3.00	5.00
A2.8(a)	Prefabricated bathroom units (PBUs) pre-assembled off-site complete with finishes, sanitary wares, concealed pipes, conduits, ceiling, bathroom cabinets, shower screen and fittings before installing in position *{Mandatory for residential non-landed projects and the residential non-landed component of mixed-use developments under the Government Land Sales Programme. The PBU system has to be accepted by the Building Innovation Panel (BIP) and accredited under the PBU Manufacturer Accreditation Scheme}*	**REPETITION OF LAYOUTS**			
		≥ 40%	no.	4.00	5.00
		< 40%	no.	3.00	4.00
A2.8(b)	Prefabricated bathroom units pre-assembled off-site complete with finishes and piping / wiring		no.	2.00	3.00
A3. 2nd Class (Lower)					
Advanced Prefabricated Systems					
A3.1	Structural steel		area	2.00	3.00
A3.2	Unitized curtain wall		length		2.00
A3.3	Prefinished wall (e.g. Precast wall with off-site finishes)		length		1.50
A3.4	Prefinished slab		area		1.50
A3.5	Prefinished ceiling		area		1.50
A3.6	Prefabricated MEP modules e.g. pipes, cable trays/trunking etc		no.	2.00	4.00
A3.7	Prefabricated MEP plant module e.g. pump, compressor etc		no.	2.00	4.00

Table 3 Design for Manufacturing and Assembly Technologies (DfMA) – N Value (continued)

DESIGN FOR MANUFACTURING AND ASSESMBLY TECHNOLOGIES (DFMA)		UNIT OF COVERAGE	N VALUE	
			PERCENTAGE OF COVERAGE[1]	
			≥ 65% TO < 80%	≥ 80%
A4. 3rd Class				
Prefabricated Components				
A4.1	Integrated precast components comprising at least 2 elements (e.g. multi-tier column/wall, double bay façade wall)	no.		1.50
A4.2	Precast external wall with cast-in windows	no.		2.00
A4.3	Mechanical connection for precast column/precast wall (horizontal joints)	no.		0.50
A4.4	Mechanical connection for precast beam joints	no.		0.50
A4.5	Mechanical connection for precast wall (vertical joints)	no.		0.50
A4.6	Prefabricated wall/facade with onsite dry applied finishes	length		1.00
A4.7	Prefabricated slab with onsite dry applied finishes	area		1.00
A4.8	Prefabricated ceiling with onsite dry applied finishes	area		1.00
A4.9	Prefabricated and pre-insulated duct for air-conditioning system[5] ***(Mandatory for all projects)***	area[6]	0.5	1.00
A4.10	Flexible sprinkler dropper[5]	no.		1.00
A4.11	Flexible water pipes[5]	no.		1.00
A4.12	Common M&E bracket (at least 3 M&E services)[5]	length		1.00

NOTE:

(1) Percentage of coverage is to be based on total area, total length or total number of components.

(2) Please refer to Section 5 for the minimum requirements and acceptance framework for PPVC.

(3) The area refers to 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.

(4) These refer to connections that do not require site welding, allow faster erection and easy on-site installation of steel members.

(5) Where points for MEP systems are awarded, the Qualified Persons shall ensure that the relevant MEP systems are adopted.

(6) The percentage of coverage is based on the area of the material used for the duct.

* Points for other DfMA technologies not shown in this table shall be determined by BCA on a case-by-case basis.

EXPLANATORY NOTES TO TABLE 3

(a) Table 3 shows the points given to each DfMA technology under 1st Class, 2nd Class (Upper), 2nd Class (Lower) and 3rd Class. Points are summed up to form the Buildable Design Score for DfMA technologies and the maximum score is 20 points.

(b) The unit of measurement for each type of DfMA technology is in number, length or area. This is specified in the column titled "Unit of Coverage."

(c) The percentage of coverage of each type of DfMA technology is classified into 2 categories:

(i) ≥ 65% to < 80%

(ii) ≥ 80%

(d) 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 for PBU systems to be accepted are spelt out in Section 3.

(h) 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. Mirror images of PBUs are treated as having the same size.

(i) BCA shall determine the points to be awarded or not to be awarded for other DfMA technologies that are not stated in Table 3. For such cases, the QPs are advised to seek BCA's comments before proceeding with the designs.

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

This section covers the performance requirements and acceptance framework for Prefabricated Bathroom Unit (PBUs) systems that are to be adopted for all residential (non-landed) and residential non-landed component of mixed-use developments on Government Land Sales (GLS) sites. 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 Performance Requirement 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 http://www.bca.gov.sg/BuildableDesign/pbu.html.

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

3.1.3 Access to Utilities for Maintenance, Repair and Replacement

(a) The vertical soil stack shall be located such that it is readily accessible from outside the PBU and within the dwelling unit or from the common areas of the same floor.

(b) 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) General information about the PBU
  (i) Introduction to the PBU
  (ii) Safety notices
  (iii) Instructions for use

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

(c) Layout of the PBU
  (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) Cleaning and maintenance advice
  (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

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 new acceptance framework for PBU systems to be used at the mandated GLS sites, 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 will be listed in BCA website at http://www.bca.gov.sg/BuildableDesign/pbu.html.

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 MINIMUM REQUIREMENTS ON LEVEL OF USE OF PREFABRICATION SYSTEMS FOR INDUSTRIAL DEVELOPMENTS ON INDUSTRIAL GOVERNMENT LAND SALES (GLS) SITES

This section covers the requirements on the minimum level of use of prefabrication systems for all industrial developments built on Industrial GLS sites with GFA of 5,000m2 or more. The minimum prefabrication level for both the structural system and wall system must be met for all affected projects.

The table below shows the minimum requirements.

Minimum Prefabrication Level	**5,000m2 ≤ GFA < 25,000m2**	**GFA ≥ 25,000m^2**
Structural System in respect of total structural floor area of the building works	25%	40%
Wall System in respect of total wall length of the building works	45%	60%

The use of the following systems as found in the Buildable Design Appraisal System (BDAS) would constitute towards the overall prefabrication level for structural system and wall system respectively in a building design:

(a) <u>Structural Systems</u>

(i) Full precast
(ii) Precast beam and precast slab
(iii) Precast column/wall and precast slab
(iv) Precast slab only
(v) Steel beam and steel column (with steel decking or precast slab)
(vi) Integrated metal roof
(vii) Metal roof

For structural systems (i) to (v), a factor of 0.7 has to be applied to the percentage of floor area using each of these systems. 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. This prefabrication level must not be lower than the stipulated minimum.

(b) <u>Wall Systems</u>

(i) Curtain wall / full height glass
(ii) Drywall
(iii) Prefabricated railing
(iv) Precast concrete wall

(viii) Lightweight concrete panel

The sum of each of the percentage of use of the above wall systems (measured by length), where applicable, would result in the prefabrication level of the wall systems adopted in the project. This prefabrication level must not be lower than the stipulated minimum.

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

This section covers the minimum requirements and acceptance framework for Prefabricated Prefinished Volumetric Construction (PPVC) systems used for the building or the component of the building on selected land parcels sold under the Government Land Sales (GLS) Programme on or after 1st December 2015. The land parcels selected are gazetted and may be found in the Building Control (Buildability and Productivity) Regulations.

The minimum level of use of PPVC shall be 65% of the total super-structural floor area of the building or the component of the building that is to be used for residential or private dwelling purposes. 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.

5.1 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.

5.2 Requirements for Prefabricated Prefinished Volumetric Construction

For the purposes of Regulation 4B(4)(b) of the Building Control (Buildability and Productivity) Regulations, 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>

5.2.1 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.

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 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 to allowed for on-site installation
Electrical sockets and light switches	100%, only light fittings allowed for on-site installation

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

Water tightness and prevention of corrosion where steel is used as the primary structural material

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

5.2.3 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.

5.2.4 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.

5.3 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).

5.3.1 Under the new acceptance framework for PPVC systems to be used at the mandated GLS sites, PPVC suppliers and manufacturers are required to submit their applications and proposals to the Building Innovation Panel (BIP).

5.3.2 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 will be listed on the BCA website at http://www.bca.gov.sg/BuildableDesign/ppvc.html. Relevant letters of In-Principle Acceptance (IPA) will also be issued to the PPVC supplier/manufacturer.

5.3.3 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) and the Structural Steel Society of Singapore (SSSS) as part of the effort to promote greater self-regulation by the industry. The accreditation criteria were jointly developed by SCI, SSSS and BCA. Further details on the accreditation scheme can be found at www.scinst.org.sg and www.ssss.org.sg

6 MINIMUM REQUIREMENTS FOR STRUCTURAL STEEL CONSTRUCTION FOR SELECTED DEVELOPMENTS ON GOVERNMENT LAND SALES (GLS) SITES

This section covers the minimum requirements for structural steel construction for buildings constructed for use solely or partly as an office on selected land parcels sold under the GLS Programme. The land parcels selected are gazetted and may be found in the Building Control (Buildability and Productivity) Regulations.

6.1 Definition

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

6.2 Minimum level of use

The minimum level of use of structural steel construction shall be 80% of the total office floor area of a building. 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.

7 EXAMPLES ON COMPUTING BUILDABLE DESIGN SCORE

7.1 A SINGLE BLOCK BUILDING PROJECT

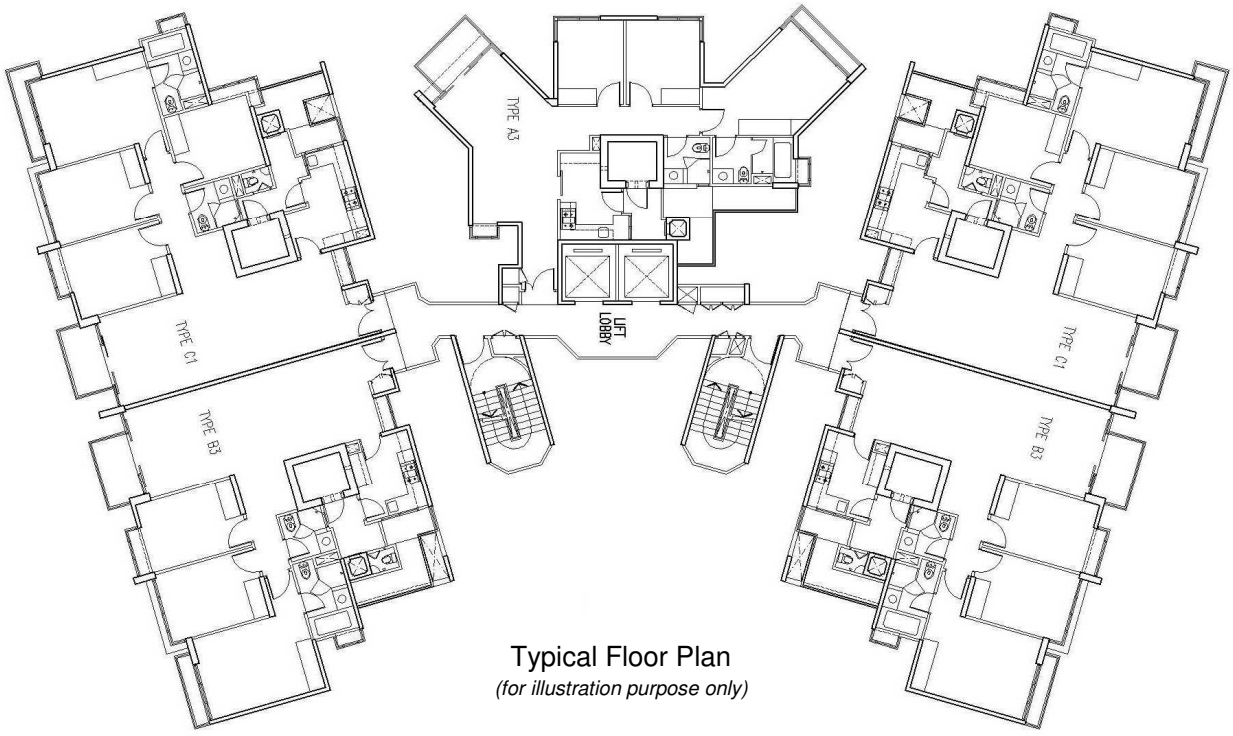
A. Project Information

- 1 block of 18-storey high residential flat
- 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

BScore = $45[\sum(A_s \times S_s)]$ + Structural Buildable Features points + $40[\sum(L_w \times S_w)]$ + C + Architectural Buildable Features points + N



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 flat plate system with cast in-situ columns with wall combination of precast walls and dry wall.

DESCRIPTION	LABOUR SAVING INDEX	AREA (m^2)	COVERAGE (%)	BUILDABLE DESIGN SCORE
Structural System				
(1) Flat plate with perimeter beams (beam depth ≤ 600 mm) for apartment area + Roof A_{sa} = 19 x 645.90 = 12,272.10m^2 A_{st} = 14,217.70m^2	S_S = 0.85	12,272.10m^2	86.32%	33.02
(2) RC beam/slab for lift lobby area + Roof A_{sa} = 19 x 102.40 = 1,945.60m^2 A_{st} = 14,217.70m^2	S_S = 0.45	1,945.60m^2	13.68%	2.77
Total		14,217.70m^2	100.00%	35.79
(3) Welded mesh for cast in-situ floor slab (mandatory with minimum 65% coverage)			86%	1.94
(4) Precast household shelters (mandatory with minimum 65% coverage)			70%	1.00
(5) Standardisation of columns (0.5M)			95%	2.00
Total (a)				**40.73**

DESCRIPTION	LABOUR SAVING INDEX	LENGTH (m)	COVERAGE (%)	BUILDABLE DESIGN SCORE
Wall System				
(1) Mandatory item - drywall as partition for internal dry areas	S_w = 1.00	1,963.90 m	18.58%	7.43
(2) Full height glass and railing	S_w = 1.00	408.60 m	3.86%	1.55
(3) Curtain wall	S_w = 1.00	717.30 m	6.78%	2.71
(4) Precast concrete wall - skim coat and paint finish	S_w = 0.90	5,204.20 m	49.22%	17.72
(5) Cast in-situ RC wall (staircase and lift shaft) - plaster & paint finish	S_w = 0.50	885.00 m	8.37%	1.67
(6) Drywall - tiled finish	S_w = 0.90	313.60 m	2.97%	1.07
(7) Brickwall	S_w = Nil	1,080.20 m	10.22%	0.00
(8) Simple design - without high voids - without complex form	 Table 2A Table 2B	 Nil Nil		 2.00 3.00
Total		10,572.80 m	100.00%	37.15
(9) Mandatory items - Typical storeys standardised to 3.15m			95%	2.00
- Standard door structural openings of 900mm, 1000mm &1200mm			90%	1.50
- Standard precast refuse chutes of 1.0m x 1.0m (outer dimensions) and 0.8m x 0.8m (inner dimensions)			100%	1.00
- Standard precast staircase of riser height of 175mm & tread width of 275mm			85%	1.00
(10) Demerit points - Brickwall			< 20%	- 2.00
Total (b)				**40.65**

DESCRIPTION			COVERAGE (%)	BUILDABLE DESIGN SCORE
DfMA Technologies (1) Accepted PBU system (repetition of layout ≥ 40) (2) Prefabricated and pre-insulated air-con ducts (mandatory) (3) Common M&E bracket			80% 70% 80%	N = 5.00 N = 0.50 N = 1.00
Total (c)				**6.50**
Buildable Design Score of Project (a) + (b) + (c)				**88**

7.2 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 = 82.0 $(A_{st})_{bldg} / (A_{st})_{proj} = 0.13$
- Block B : B-Score = 82.0 $(A_{st})_{bldg} / (A_{st})_{proj} = 0.13$
- Block C : B-Score = 82.0 $(A_{st})_{bldg} / (A_{st})_{proj} = 0.13$
- Block D : B-Score = 84.0 $(A_{st})_{bldg} / (A_{st})_{proj} = 0.14$
- Block E : B-Score = 83.0 $(A_{st})_{bldg} / (A_{st})_{proj} = 0.12$
- Block F : B-Score = 85.0 $(A_{st})_{bldg} / (A_{st})_{proj} = 0.13$
- Block G : B-Score = 73.2 $(A_{st})_{bldg} / (A_{st})_{proj} = 0.05$
- Block H : B-Score = 86.2 $(A_{st})_{bldg} / (A_{st})_{proj} = 0.17$

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

B-Score_{proj} = Sum of $[\text{B-Score}_{bldg} \times (A_{st})_{bldg} / (A_{st})_{proj}]$

= **83**

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 system 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	$\frac{\sum(\text{Length with external access system/no external scaffold} \times \text{Allocated pts})}{\text{Total Building Perimeter}}$
(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	$\frac{\sum(\text{Vertical Formwork Contact Area} \times \text{Allocated points})}{\text{Total Vertical Formwork Contact Area}}$
(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	$\frac{\sum(\text{Floor Area} \times \text{Allocated points})}{\text{Total Floor Area}}$
(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 ≥ 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 formwork 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 pre-fabricated 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 macro (project-wide) productivity improvements for the project and two new key trades' micro (trade or process specific) productivity improvements. 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 minimising 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 & 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)		
(a) 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)	**9.57**
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 minimising 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)	**4**
Total Constructability Score = Sub-total (A) + Sub-total (B) + Sub-total (C)		**64** **> 60 (min)**

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 $A_{fw} = 20{,}000m^2$
- Block B $A_{fw} = 25{,}000m^2$
- Block C $A_{fw} = 35{,}000m^2$

  Overall project $A_{fw} = 80{,}000m^2$

B. Constructability Score

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

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

The Constructability Score of the project is computed as below:

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

= **63**