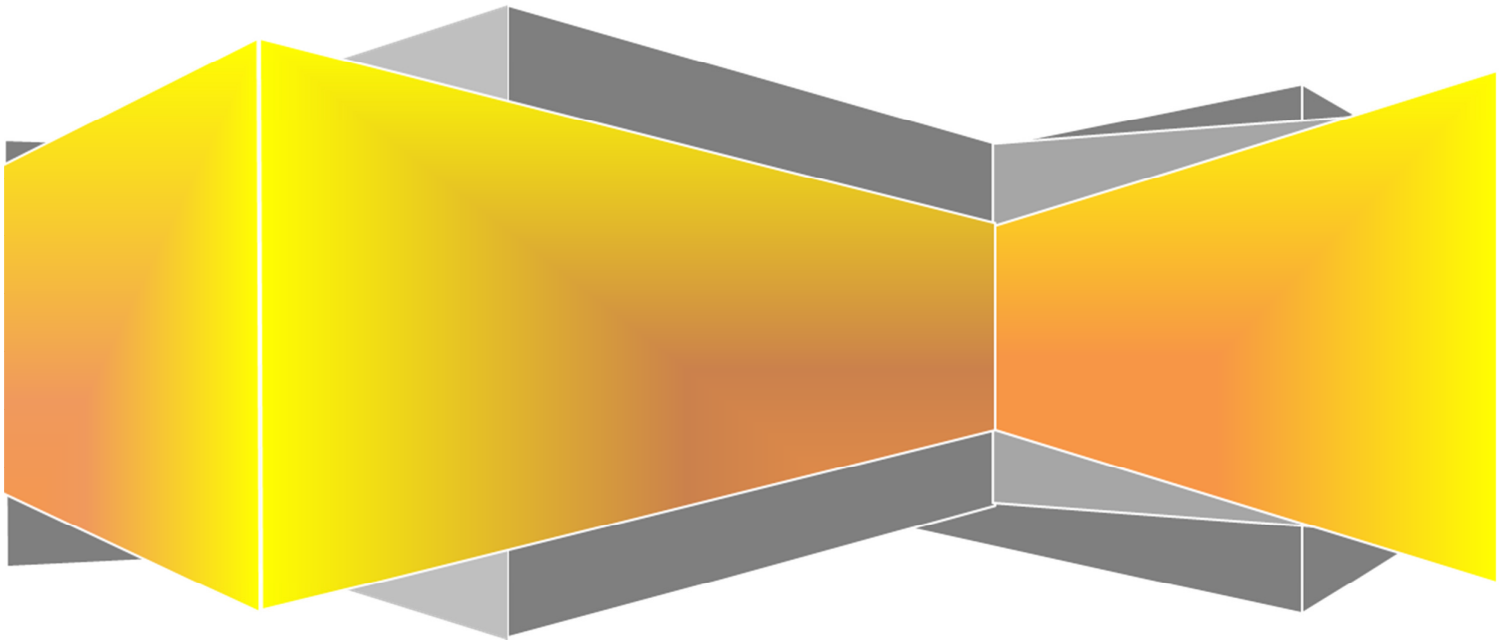
Building and Construction Authority

CODE OF PRACTICE ON

Buildability

2014 Edition



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

Building and Construction Authority

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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 standardization 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, from this year onwards, BCA has mandated the adoption of key productivity components including industry-wide standard dimensions 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.

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 and buildable features 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	The lowest Buildable Design Score allowed under a particular category of development 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 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 5 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 As-built Buildable Design Score achieved.

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
Residential (non-landed)	• Condominium • Flat • Service apartment • Apartment • Dormitory • Hostel

Table A Categories of Building *(continued)*

CATEGORIES	TYPES OF DEVELOPMENT
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 • Sub-station
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 • Cinema/Theatre • Sports/Recreational facilities • Public transport 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 Score of the 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 various types of structural system used.

Part 2 - Wall System (maximum 45 points). Points are awarded for various types of wall system used.

Part 3 - Other Buildable Design Features (maximum 10 points). Points are awarded for standardisation, modular dimensions and use of precast/prefabricated components.

In addition to the above, bonus points are obtainable in Part 1, Part 2 and Part 3 for the use of productive technologies such as mechanical connections for precast joints, self-compacting concrete, simple design, dry construction and mechanical, electrical & plumbing (MEP) systems, high impact productive and modern construction systems as well as the adoption of single integrated components and industry-wide standardisation of building components / design parameters.

The maximum Buildable Design Score achievable for a project is capped at 100 points.

5.2 Types of Development

5.2.1 The minimum Buildable Design Score requirement 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 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 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 Subject to 5.3.2 below, for new building works and A&A works outside existing building (considered as new work) including those developed by the public sector agencies i.e. Government Procurement Entities which are submitted for planning permission on or after 1st November 2014, the minimum Buildable Design Scores for each category of development, namely residential projects, commercial projects, industrial projects, school projects and institutional and other projects are tabulated in Table B. 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 November 2014.

5.3.2 For building works that are developed by key Government Procurement Entities namely HDB, JTC, MOH, MOE, MOT, LTA, PA, NEA, SPF and SPORTSSG which are submitted for planning permission on or after 1st November 2014, the minimum Buildable Design Scores for each category of development are tabulated in Table C.

5.3.3 Different minimum Buildable Design Score requirements are given for 2,000 $m^2 \leqslant$ GFA < 5,000 m^2, 5,000 $m^2 \leqslant$ GFA < 25,000 m^2 and GFA $\geqslant$ 25,000 m^2.

Table B Minimum Buildable Design Score for All New Building Works including those by Government Procurement Entities and Building Works on Land Sold under the Government Land Sales Programme#

CATEGORY OF BUILDING WORK/ DEVELOPMENT	MINIMUM BUILDABLE DESIGN SCORE		
	2,000 $m^2 \leqslant$ GFA < 5,000 m^2	5,000 $m^2 \leqslant$ GFA < 25,000 m^2	GFA $\geqslant$ 25,000 m^2
Residential (landed)	70	75	78
Residential (non-landed)	77	82	85
Commercial	79	84	87
Industrial	79	84	87

Table B **Minimum Buildable Design Score for All New Building Works including those by Government Procurement Entities and Building Works on Land Sold under the Government Land Sales (GLS) Programme*** ***(continued)***

CATEGORY OF BUILDING WORK/ DEVELOPMENT	MINIMUM BUILDABLE DESIGN SCORE		
	2,000 m^2 ⩽ GFA < 5,000 m^2	5,000 m^2 ⩽ GFA < 25,000 m^2	GFA ⩾ 25,000 m^2
School	74	79	82
Institutional and others	70	76	79

** 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. These minimum scores shall also supersede those scores as shown in Table E and Table F of the COP on Buildability, 2013 Edition.*

Table C **Minimum Buildable Design Score for New Building Works by Key Government Procurement Entities which include HDB, JTC, MOH, MOE, MOT, LTA, PA, NEA, SPF and SPORTSSG#**

CATEGORY OF BUILDING WORK/ DEVELOPMENT	MINIMUM BUILDABLE DESIGN SCORE		
	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.

5.3.4 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

5.3.5 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*
On or after 1st November 2014	Code of Practice on Buildability *2014 edition*

5.3.6 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
		5,000 m^2 ⩽ GFA < 25,000 m^2
Residential (non-landed)	70% of GFA	70% of 82* = 57.40
Commercial	30% of GFA	30% of 84* = 25.20
The required minimum Buildable Design Score	100% of GFA	**83 (rounded to nearest integer)**

**based on 1st November 2014 minimum buildable design scores for new work*

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
		GFA ⩾ 25,000 m^2
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 November 2014 minimum buildable design scores for new work*

5.3.7 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 m^2 ⩽ GFA < 25,000 m^2
A&A work within existing building	20% of GFA	20% of 62 = 12.40
Work outside existing building	80% of GFA	80% of 84* = 67.20
The required minimum Buildable Design Score	100% of GFA	**80 (rounded to nearest integer)**

**based on 1st November 2014 minimum buildable design scores for new work*

6 SUBMISSION PROCEDURES FOR BUILDABLE DESIGN SCORE REQUIREMENTS

Buildable Design Score and the Buildability Detailed Design and Implementation Plan are one of the requirements for Building Plan (BP) approval. The BP will not be approved if the submitted Buildable Design Score is lower than the stipulated minimum. The Buildable Design Score and the Buildability Detailed Design and Implementation Plan are to be submitted by QPs at the following stages:

- BP stage
- ST (Structural plan) superstructural 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 Score is to be submitted together with the BP submission using Form BPD_BS01. The Buildable Design Score is to be jointly declared by the QP for Architectural Works and the QP for Structural Works and the detailed computation of the Buildable Design Score 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 Score 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 and any buildable feature;

- the elevation plans and sectional plans which clearly mark out the types of structural system, wall system 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 of all buildable features to be constructed for the building works etc.

6.2 Submission at ST Superstructural 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 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 Score is to be submitted by the QP for Structural Works at the ST superstructural stage using Form BEV/ A1_BS02. The Structural Buildable Design Score is to be jointly declared by the QP for Architectural Works and the QP for Structural Works. Forms BEV/A1 and 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 Score 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 and any buildable feature;

- the elevation plans and sectional plans which clearly mark out the types of structural system 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 of all 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 and buildable feature 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 Score 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 Score which must not be lower than the stipulated minimum. Both the amended Buildability Detailed Design and Implementation Plan and the amended Buildable Design Score 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 Score of the building works as completed (referred to as the record plans of Buildable Design Score) 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 Score 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 50 points). Points are awarded for various methods and technologies adopted during the construction of AMEP works.

Part C - Good Industry Practices (maximum 10 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 methods, systems, processes, plant and equipment 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 method, system, process, plant and equipment 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 Subject to 7.3.2 below, the minimum Constructability Score for each category of development, namely residential projects, commercial projects, industrial projects, school projects and institutional and other projects including those developed by the public sector agencies i.e. Government Procurement Entities which are submitted for planning permission on or after 1st November 2014 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 November 2014.

7.3.2 For building works that are developed by key Government Procurement Entities namely HDB, JTC, MOH, MOE, MOT, LTA, PA, NEA, SPF and SPORTSSG which are submitted for planning permission on or after 1st November 2014, the minimum Buildable Design Scores for each category of development are tabulated in Table J.

7.3.3 Different minimum Constructability Score requirements are given for 5,000 $m^2 \leqslant$ GFA < 25,000 m^2 and GFA $\geqslant$ 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 New Building Works including those by Government Procurement Entities and Building Works on Land Sold under the Government Land Sales (GLS) Programme*

CATEGORY OF BUILDING WORK / DEVELOPMENT	MINIMUM CONSTRUCTABILITY SCORE	
	5,000 m^2 ≤ GFA < 25,000 m^2	GFA ≥ 25,000 m^2
Residential (landed)	47 (min 32 points from Structural System)	57 (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. These minimum scores shall also supersede those scores as shown in Table O and Table P of the COP on Buildability, 2013 Edition.*

Table J Minimum Constructability Score for New Building Works by Key Government Procurement Entities which include HDB, JTC, MOH, MOE, MOT, LTA, PA, NEA, SPF and SPORTSSG#

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.

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*
On or after 1st November 2014	Code of Practice on Buildability *2014 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 BE_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

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.

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 result in more efficient labour usage in construction and therefore higher site labour productivity.

1.1 Objective

The objective of BDAS is to result in the wider use of buildable design. 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 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 whether formwork or precast 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 precast components reduces many trade operations on site and should improve site productivity provided the standardisation principles are observed.

Single integrated elements are those that combine related components together into a single element that may be prefabricated in the factory and 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 totalled 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 and others. 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 and other buildable features. The maximum Buildable Design Score achievable for a project is 100 points.

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

1.6 Rationale on Derivation of Labour Saving Indices

One of the more 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 the 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, 2014 Edition, has included a number of updates.

1.8.1 Mandatory Adoption of Components for Certain Development Types

The following components including the dimensions/sizes as specified, where applicable, are mandated for the development types as shown below :

(a) Drywall as internal partitions for dry areas in all residential non-landed developments.

(b) Standard door structural openings for all residential non-landed developments.

(c) Standard precast refuse chutes for all residential non-landed developments.

(d) Standard storey heights for all residential non-landed developments and office developments.

(e) Standard prefabricated staircases for all types of development.

1.8.2 Mandatory Adoption of Specific Productive Technologies for New Developments Sold under the Government Land Sales (GLS) Programme

Under land sales conditions, the following high impact productive technologies are mandated for the specific developments sold under the GLS Programme from 1st November 2014 :

(a) Minimum adoption rate of Prefabricated Bathroom Units (PBUs) for all residential non-landed developments.

(b) Minimum level of use of Prefabrication Systems for all industrial developments with GFA of at least 5,000 m^2.

(c) Minimum level of Prefabricated Prefinished Volumetric Construction (PPVC) for selected land parcels.

The requirements and details for each of the above productive technologies have been spelt out in the relevant sections.

1.8.3 Wall System

The key changes are listed below:

(a) Definition of drywall system mandated for use as internal partitions in all residential non-landed developments has been included.

(b) Bonus points for “Off-form cast in situ concrete external walls and columns” and “Off-form precast concrete external walls and columns” have been removed. Instead, LSIs for “Off-form (external walls and columns only)” have been given under the “Precast Concrete Wall” and “Cast In-situ RC Wall” systems.

(c) The LSI for “Brickwall / Blockwall” has been removed. The use of brickwall / blockwall are given demerit points under the part on “Other Buildable Design Features”.

1.8.4 Other Buildable Design Features

The key changes are listed below:

(a) Some of the industry-wide standardised prefabricated bathroom sizes have been revised.

(b) The measurement for percentage of coverage for use of engineered timber flooring has been amended.

(c) Bonus points have been awarded for the use of engineered stone flooring finishes.

(d) Bonus points have been awarded for the use of prefabricated pre-finished volumetric construction and engineered timber construction.

(e) Demerit points have been introduced for the use of brickwall / blockwall.

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) Other Buildable Design Features.

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 prefabricated reinforcement, 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, bonus points are also given for the use of recommended precast joints from specified publications with the aim to improve the quality of precast design which will facilitate ease of precast production and installation. Other items that are recognized with bonus points include the use of mechanical connections for precast joints, high strength concrete, self-compacting concrete and diaphragm wall.

The maximum Buildable Design Score achievable under this section on structural systems including the bonus points given 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 for designs with complex forms such as buildings that are designed with high voids, tilts, bends and twists, up to 5 direct points are awarded to designs that are simple to construct.

The maximum Buildable Design Score achievable for wall systems is 45 points.

Buildable Design Score of Other Buildable Design Features

In this section, the buildability of the design is examined at the detailed level. Basic design characteristics, namely standardisation of columns, beams, windows and doors, grids and other buildable design features such as the usage of prefabricated/precast components and floor without screeding or drops/kerbs are considered. Standard floor heights, door structural openings, precast refuse chutes and prefabricated staircases mandated for specific types of projects are also included. The use of these buildable design features will be awarded with points directly. The maximum Buildable Design Score that can be achieved in this section is 10 points.

In addition, bonus points are given for the use of single integrated components such as prefabricated bathroom units, precast household shelters and external precast walls with cast-in windows. To encourage greater standardization, the use of industry-wide standardised floor heights with standard precast staircases, industry standard door structural openings and precast refuse chutes (in projects for which such standard components are not mandated), as well as industry-wide standardised precast household shelters and prefabricated bathroom units are also given bonus points. On top of these, designs that adopt dry construction such as the use of drywall for party wall and wet areas, labour-saving mechanical, electrical and plumbing (MEP) systems such as flexible sprinkler dropper and modern construction system such as cross laminated timber are also recognised with bonus points. The maximum bonus points that can be achieved here is 20 points.

Overall, the maximum Buildable Design Score achievable under the 3 main parts of Structural System, Wall System and Other Buildable Design Features is 120 points. However, the Buildable Design Score of any design is capped at 100 points.

2.2 Computation of Buildable Design Score

The Buildable Design Score formula is expressed as:

Buildable Design Score (B-Score) of Building	=	Buildable Design Score of Structural System (including Roof System) + Buildable Design Score of Wall System + Buildable Design Score of Other Buildable Design Features
B-Score	=	$\{45[\sum(A_s x S_s)] + \text{Structural Bonus points}\}^{\#} + \{40[\sum(L_w x S_w)] + C\}^{\#} + N + \text{Bonus points}$
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 bonus points	=	Bonus points for the use of recommended precast joints, mechanical connections for precast joints, high strength concrete, self-compacting concrete and diaphragm wall (Table 1)
S_w	=	Labour saving index for external & internal wall system (Table 2)
C	=	Bonus points for simple designs (Table 2)
N	=	Buildable Design Score for other buildable design features (Table 3)
Bonus points	=	Bonus points for the use of single integrated components, industry standard building components/design parameters, dry construction, labour-saving MEP systems and modern construction system (Table 3)

 # capped at 45 points

The Buildable Design Score of a project which consists of more than one building should be computed by multiplying the respective Buildable Design Score 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 Bonus 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 bonus points : Various labour-saving structural design considerations are given bonus points as shown in Table 1. The maximum bonus 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 is the total floor area constructed in the project, and includes roof (projected area) and basement area.

The maximum Buildable Design Score for the structural system inclusive of structural bonus points is 45 points

(b) Buildable Design Score of Wall System

The score for the wall system is based on:

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

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 : Bonus 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.

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 includes all external and internal walls but exclude external basement wall for earth retaining purpose.

The maximum Buildable Design Score for wall system is 45 points.

(c) Buildable Design Score of Other Buildable Design Features, N value

This section covers other design considerations that contribute to labour saving on site. Points are given for each labour saving method adopted and these are summed up to give the score, up to a maximum of 10 points. The points of various design considerations are given in Table 3.

(d) Buildable Design Score of Single Integrated Components, Industry standard building components/design parameters, Dry construction, Labour-saving MEP systems and Modern Construction System, Bonus points

Bonus points are given for the use of single integrated components such as prefabricated bathroom units, precast household shelters and external precast walls with cast-in windows, as well as industry-wide standardised building components and design parameters such as floor heights with standard precast staircases, door structural openings etc. In addition, designs that adopt dry construction such as the use of drywall for party wall and wet areas, labour-saving MEP systems such as flexible sprinkler dropper and modern construction system such as engineered timber are also recognised with bonus points. These bonus points are summed up to give the score, up to a maximum of 20 points. The points for these components are given in Table 3.

The maximum overall Buildable Design Score is capped at 100 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 Structural Systems (continued)

Bonus Points

DESCRIPTION	DIRECT POINTS
Recommended precast joint types (≥ 65%)[3][4]	3.00
Mechanical connection for precast column joints (≥ 65%)[5]	0.50
Mechanical connection for precast beam joints (≥ 65%)[5]	0.50
Mechanical connection for vertical precast wall joints (≥ 65%)[5]	2.00
High strength concrete (≥ Grade 70, at least 5%)[6]	1.00
Self-compacting concrete (≥ 30%)[7]	2.00
Diaphragm wall (≥ 65% length of basement permanent retaining wall) [8]	2.00

NOTE:

(3) Recommended precast joint types refer to those found in the following guides:
- (i) BCA's Buildable Solutions for High-Rise Residential Development
- (ii) BCA's Structural Precast Concrete Handbook
- (iii) BCA's Buildable Solutions for Landed Residential Development in Singapore
- (iv) HDB's Precast Pictorial Guide

(4) At least 65% of the precast joint types used in a project must come from any of the publications mentioned in [3].

(5) At least 65% of the precast component must use mechanical connection.

(6) High strength concrete of at least Grade 70 must be used for at least 5% of the total concrete volume.

(7) Self-compacting concrete must be used for at least 30% of the total concrete volume.

(8) 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.

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

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

<u>Example of prefabricated reinforcement in cast in-situ floor</u>

Area of precast floor = 3,000 m^2

Area of cast in-situ floor using prefabricated reinforcement (mesh) = 7,000 m^2

Total floor area including roof area = 10,000 m^2

Percentage of coverage = area of cast in-situ floor using mesh/total floor area

= 7000/10000

= 70%

Therefore, points awarded = 0.05 x 0.70 x 45

= 1.58

<u>Example of prefabricated reinforcement in cast in-situ columns</u>

Total number of precast columns = 255

Total number of cast in-situ columns using prefabricated cage = 525

Total number of columns = 780

Percentage of coverage = Total no. of cast in-situ columns using prefabricated cage/total no. of columns

= 525/780

= 67%

Therefore, points awarded = 0.05 x 0.67 x 45

= 1.51

(g) The maximum bonus points 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 Table 3[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. Demerit points for the use of brickwall/blockwall will be computed under Table 3.

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

Bonus Points for Simple Design

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

Table 2A: Bonus 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)	2.0
2	0% < % of high void < 10%	1.5
3	10% ≤ % of high void < 15%	1.0
4	15% ≤ % of high void < 20%	0.5
5	% of high void ≥ 20%	0

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: Bonus 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.

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, magnesium oxide 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.

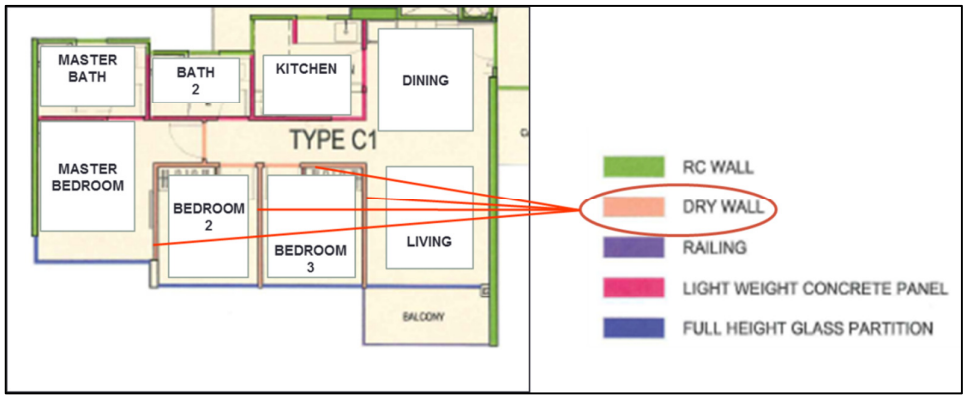


Figure 1 – Example of a layout showing the mandatory use of drywall for all internal dry areas.

(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.

Table 3 Other Buildable Design Features – N Value

BUILDABLE FEATURES		MODULE	UNIT OF COVERAGE	N VALUE	
				PERCENTAGE OF COVERAGE[4]	
				≥70% TO < 90%	≥ 90%
1. Mandatory Components					
1.1(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
1.1(b)	Typical storeys standardised to either 4.2m, 4.5m, 4.55m, 4.8m or 4.9m height (*applicable to office projects only*)		no.		2.00
1.2	Standard door structural openings (width) (3 most common sizes) *(see Table 3A)* (*applicable to residential non- landed projects only*)		no.	0.50	1.50
1.3	Standard precast refuse chutes *(see Table 3B)* (*applicable to residential non- landed projects only*)		no.	0.50	1.00
1.4(a)	Standard prefabricated staircase of riser height of 150mm or 175mm & tread width of 275mm or 300mm (*applicable to all projects except industrial projects*)		no.	1.00	2.00
1.4(b)	Standard precast staircase of riser height of 150mm or 175mm & tread width of 250mm, 275mm or 300mm (*applicable to industrial projects only*)		no.	1.00	2.00
2. Standardisation					
2.1	Columns (3 most common sizes)	0.5M[2]	no.	1.50	2.00
2.2	Beams (3 most common sizes)	0.5M[2]	no.	1.50	2.00
2.3	Door structural openings (width) (3 most common sizes)	0.5M	no.	0.75	1.00
2.4	Windows (3 most common sizes)[1]	1M/1M[3]	no.	0.75	1.00
3. Grids					
3.1(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
3.1(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
3.2(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
3.2(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
3.3	Repetition of horizontal grids	6M	no.	1.50	2.00

NOTE:

(1) Sizes based on dimensions of frames.

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

(3) 1M for width and 1M for height (1M = 100 mm).

(4) Percentage of coverage is to be based on total floor area or on total number of components such as columns, beams, doors, windows etc.

BUILDABLE FEATURES		MODULE	UNIT OF COVERAGE	N VALUE	
				PERCENTAGE OF COVERAGE[4]	
				≥70% TO < 90%	≥70% TO < 90%
4. Others					
4.1	Multi-tier precast columns		no.	1.00	2.00
4.2	Precast or pre-assembled/ metal staircases		no.	1.00	2.00
4.3	Precast meter chambers *(for landed residential developments)*		no.	0.50	1.00
4.4	Prefabricated MEP risers		no.	0.50	1.00
4.5	No screeding for any flooring		area	1.50	3.00
4.6	Single floor level without drops/kerbs within apartment unit *(e.g. at kitchen, toilets)*		no.	1.00	2.00
Single Integrated Components		**REPETITION OF LAYOUTS**	**UNIT OF COVERAGE**	**PERCENTAGE OF COVERAGE[4]**	
				≥65% TO < 80%	**≥ 80%**
A.1(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)}.*	≥ 40	no.	5.00	6.00
		< 40	no.	3.00	4.00
A.1(b)	Prefabricated bathroom units pre-assembled off-site complete with finishes and piping / wiring		no.	2.00	3.00
A.2	Precast household shelter		no.	1.00	2.00
A.3	Precast external wall with cast-in windows		no.	1.00	2.00
Bonus Points		**MODULE**	**UNIT OF COVERAGE**	**PERCENTAGE OF COVERAGE[4]**	
				≥65% TO < 80%	**≥ 80%**
Industry Standardisation					
A.4(a)	Typical storeys standardised to either 2.8m, 2.975m, 3.15m, 3.3m, 3.5m, 3.6m, 4.2m, 4.5m, 4.55m, 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
A.5	Standard door structural openings (3 most common sizes) *(see Table 3A)*		no.	0.50	1.50
A.6	Standard precast refuse chutes *(see Table 3B)*		no.	0.50	1.00
A.7	Standard precast household shelters (3 most common sizes) *(see Table 3C)*		no.	1.00	2.00
A.8	Standard prefabricated bathroom units (applicable to item A.1(a) or A.1(b)) (3 most common sizes) *(see Table 3D)*		no.	1.00	2.00

Bonus Points		MODULE	UNIT OF COVERAGE	PERCENTAGE OF COVERAGE[4]	
				≥65% TO < 80%	≥ 80%
Finishes & Dry Construction					
A.9	Drywall for party wall (*applicable for residential projects only)*		no.	2.00	4.00
A.10	Drywall for wet areas (kitchens and toilets) (*applicable to residential projects only)*		no.	1.50	3.00
A.11	Engineered timber flooring *(applicable to residential projects only)*		area	1.00	2.00
A.12	Carpet, vinyl and raised floor		area	1.00	2.00
A.13	Engineered stone flooring finishes		area	1.00	2.00
Mechanical, Electrical and Plumbing (MEP) Systems[5]					
A.14	Prefabricated and pre-insulated duct for air-conditioning system[6] *(for central air conditioning system only)*		area	2.00	4.00
A.15	Flexible sprinkler dropper		no.	1.00	2.00
A.16	Flexible water pipes		no.	0.50	1.00
A.17	Common M&E tray (at least 3 M&E services)		length	1.00	2.00
Modern Construction System		**MODULE**	**UNIT OF COVERAGE**	**PERCENTAGE OF COVERAGE**	
				≥ 65%	
A.18	Prefabricated Prefinished Volumetric Construction (PPVC)[7]		area	6.00	
A.19	Engineered Timber {e.g. Cross Laminated Timber (CLT)}		area[8]	3.00	

NOTE:

(5) Where bonus points for MEP 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.

(7) A building is deemed to be constructed using PPVC if it meets the requirements spelt out in Section 5.

(8) 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.

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

B. Demerit Points		MODULE	UNIT OF COVERAGE	PERCENTAGE OF COVERAGE	POINT DEDUCTION
B.1	Non-functional void on slab[9]				-1.00
B.2	Cast in-situ floor with transfer beam[10]		no.	< 30%	-1.00
				≥30% to <60%	-1.50
				≥60%	-2.00
B.3	Cast in-situ floor with cantilever transfer beam[10]		no.	< 30%	-2.00
				≥30% to <60%	-2.50
				≥60%	-3.00
B.4	Inclined columns[11]		no.	< 30%	-1.00
				≥30%	-1.50
B.5	Brickwall / Blockwall[12]		length	< 20%	-2.00
				≥20%	-3.00

NOTE:

(9) 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.

(10) 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.

(11) 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.

(12) 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 3

(a) Table 3 Items 1, 2, 3 and 4 show the points given to each buildable design feature that contributes to labour saving on site. Points are summed up to form the Buildable Design Score for the buildable design features in these sections. The maximum score for buildable design features shown in Sections 1, 2, 3 and 4 is 10 points.

(b) Points are also given to single integrated components, industry standardisation of building components/design parameters, dry construction, MEP system and modern construction system as shown in Item A. The maximum bonus points given under this Item is capped at 20 points.

(c) For Item 1 – Mandatory components, these are applicable to specific types of projects as stated. Points claimed for these mandatory components cannot be duplicated for claiming of bonus points.

(d) For Item 2 – Standardisation, 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.

(e) For Item 3 – Grids, the criteria of minimum module must be met before points are given. M denotes 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

(f) The unit of measurement for each type of design feature is in number or area. This is specified in the column entitled “Unit of Coverage.”

(g) The percentage of coverage of each type of design feature is generally classified into 2 categories:

(i) ≥ 70% to < 90%

(ii) ≥ 90%

In the case of single integrated components and design features awarded with bonus points, the percentage of coverage is classified into the following categories:

(i) ≥ 65% to < 80%

(ii) ≥ 80%

(h) 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 production 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.

(i) 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.

(j) Demerit points are given to designs that have voids on slabs, transfer beams, inclined columns and for use of brickwall / blockwall as shown in Item B. The maximum demerit points deducted under this Item is capped at 5 points.

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

Table 3A: Industry Standard Door Structural Openings

S/No	Door Structural Opening (Width) (mm)
1	900
2	1000
3	1100
4	1200
5	1500
6	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 3 – Item 1.2.
2. For other types of projects, bonus 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 3 – Item A.5.

Table 3B: 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 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 3 – Item 1.3.
2. For other types of projects, bonus 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 3 – Item A.6.

Table 3C: 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	250 or 300
75 < GFA ≤ 140	2.8	1.2 x 2.4, 1.3 x 2.2	250 or 300
GFA > 140	3.4	1.5 x 2.4, 1.6 x 2.2	250 or 300

NOTE:
Bonus 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 3 – Item A.7.

Table 3D: 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	1.8 x 2.8	1.2 x 1.5
2.0 x 2.6	1.9 x 1.9	1.2 x 1.6
2.0 x 3.4	2.0 x 2.0	1.2 x 2.2
2.2 x 2.8		

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. Bonus 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 3 – Item A.8, 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.

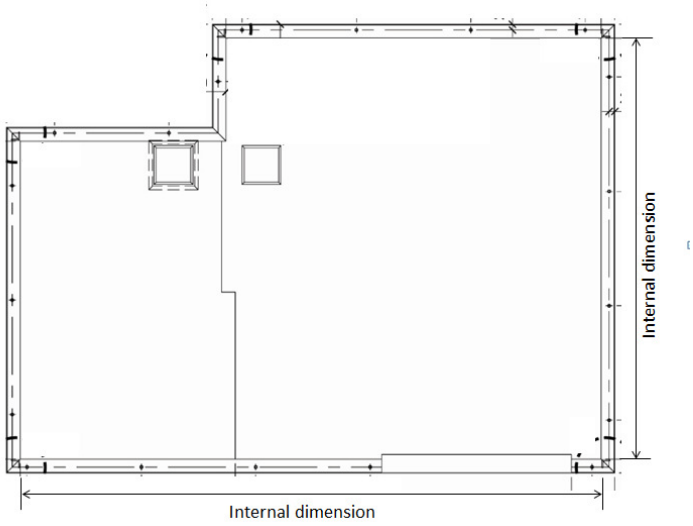


Figure 2 – Plan of a prefabricated bathroom unit and its internal dimensions

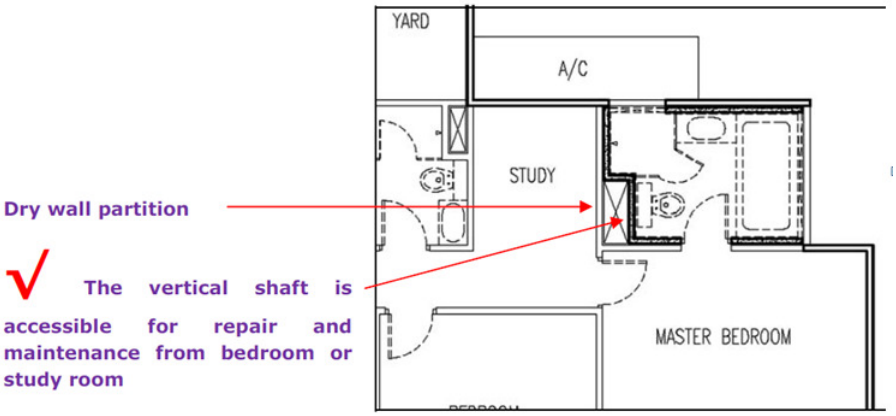


Figure 3 – Example of a layout of a prefabricated bathroom unit with a services shaft that is accessible for future repairs and maintenance

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 with 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.

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

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

(c) <u>Layout of the PBU</u>
  (i) General layout of the PBU
  (ii) Locations of concealed services
  (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 on the BCA website at http://www.bca.gov.sg/BuildableDesign/pbu.html.

3.2.3 In addition, the production 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. Further details on the accreditation scheme can be found at www.scinst.org.sg.

4 REQUIREMENTS ON 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 5,000m^2 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	**GFA ≥ 5000m^2**	**GFA ≥ 25000m^2**
Structural System In respect of total structural floor area of the building works	20%	35%
Wall System In respect of total wall length of the building works	35%	50%

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 0.5 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 REQUIREMENTS FOR PREFABRICATED PREFINISHED VOLUMETRIC CONSTRUCTION (PPVC)

This section covers the minimum requirements for Prefabricated Prefinished Volumetric Construction (PPVC). For selected land parcels sold under the Government Land Sales (GLS) Programme on or after 1st November 2014, the building or the component of the building shall be built using PPVC. The land parcels selected are gazetted and can be found in the Building Control (Buildability and Productivity) Regulations.

The minimum level of use of prefabricated prefinished volumetric construction 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" (or "PPVC") means a construction method whereby free-standing volumetric modules complete with finishes for walls, floors and ceilings are constructed and assembled outside the premises of the building works and installed at those premises for the purposes of those building works.

5.2 Requirements for Prefabricated Prefinished Volumetric Construction

For the purposes of Regulation 4B(4)(2) of the Building Control (Buildability and Productivity) Regulations, the volumetric modules used for PPVC shall comply with the following requirements:

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

5.2.1 The extent of finishing and fittings to be completed off-site for the volumetric modules shall comply to 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	30%, only prefinished timber floor allowed for on-site installation
Wall finishes	100%
Painting	100% base coat, only final coat is allowed on-site
Windows frame	100%, only glazing allowed for on-site installation
Door frame	100%, only door leaves allowed for on-site installation
Wardrobe and Cabinets	100%, only wardrobe and cabinet doors allowed for on-site installation.
M&E including water and gas piping, wiring, ducting	100%, only equipment and fixtures to allowed for on-site installation
Air-conditioning drain pipe	100%, only air-conditioning Fan Coil Units (FCU) and condenser unit 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 over the modules); and
(b) allow water entering the building external to and between the volumetric modules to be properly discharged and drained completely.

5.2.4 Floor areas intended to be wet (e.g. bathrooms, kitchens) shall be treated with waterproofing membrane to ensure water-tightness.

5.2.5 High density polyethylene pipes (HDPE) shall be used for all inlet and discharge piping.

6 EXAMPLES ON COMPUTING BUILDABLE DESIGN SCORE

6.1 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

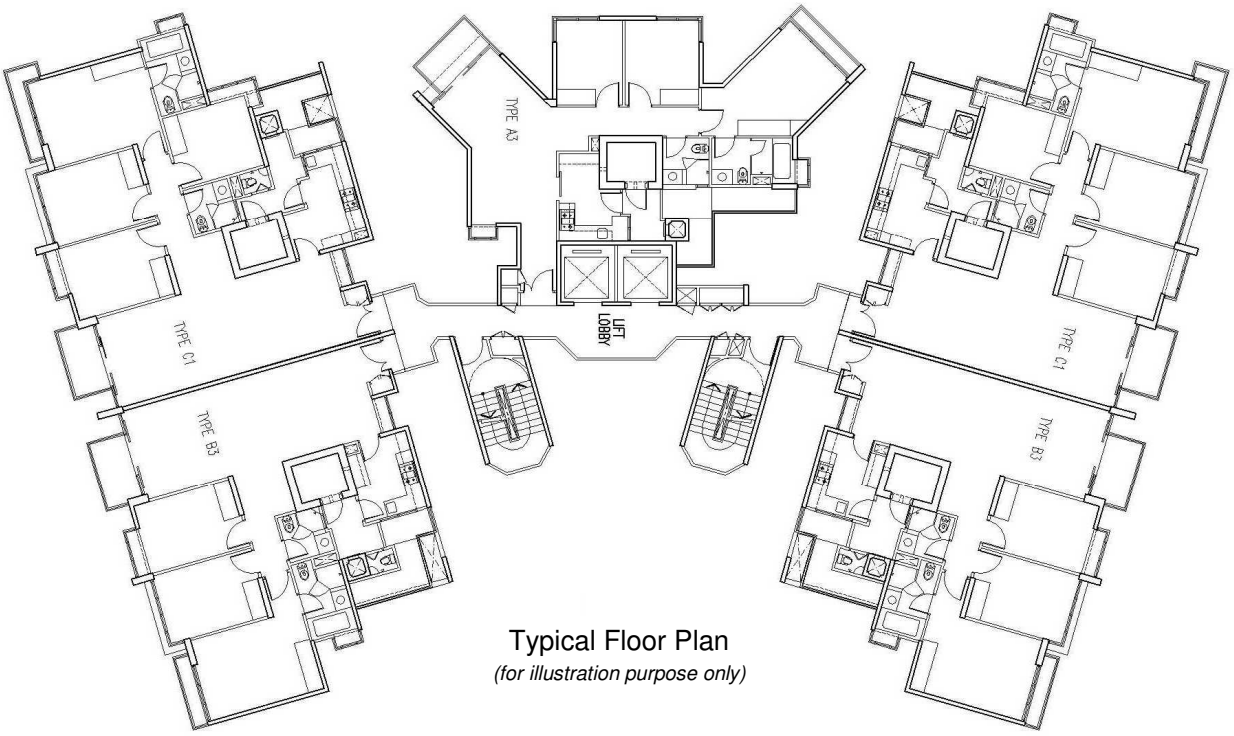
  Total floor area of Lift Lobby = 18 x 102.40m² = 1,843.20m²

  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

BDScore = $45[\sum(A_s \times S_s)]$ + Structural Bonus points + $40[\sum(L_w \times S_w)]$ + C + N + Bonus Points



Typical Floor Plan

(for illustration purpose only)

Area of residential units per floor	=	129.18 x 5
	=	645.90 m^2
Lift lobby area per floor	=	102.40 m^2
Typical floor area	=	645.90 + 102.40
	=	748.30 m^2

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) or LENGTH(m)	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
Use of prefabricated reinforcement Welded mesh for cast in-situ floor slab 86% of total floor area	0.05		86.00%	1.94
Total (a)				**37.73**
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 A Table B	Nil Nil		2.00 3.00
Total (b)		10,572.80 m	100.00%	**37.15**

DESCRIPTION	LABOUR SAVING INDEX	AREA(m^2) or LENGTH(m)	COVERAGE (%)	BUILDABLE DESIGN SCORE
Buildable Features				
(1) Mandatory components - Typical storeys standardised to 3.15m			95%	N = 2.00
- Standard door structural openings of 900mm, 1000mm &1200mm			90%	N = 1.50
- Standard precast refuse chutes of 1.0m x 1.0m (outer dimensions) and 0.8m x 0.8m (inner dimensions)			100%	N = 1.00
- Standard prefabricated staircase of riser height of 175mm & tread width of 275mm			95%	N = 2.00
(2) Standardisation of columns (0.5M) 3S at 95%			95%	N = 2.00
Single Integrated Components (3) Accepted PBU system			65%	N = 4.00
Bonus Points (4) Common M&E tray			65%	N = 1.00
Demerit Points (5) Brickwall			<20%	N = -2.00
Total (c)				**11.50**
Buildable Design Score of Project (a) + (b) + (c)				**86**

6.2 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 = 78.0 $(A_{st})_{bldg} / (A_{st})_{proj} = 0.13$
- Block G : B-Score = 63.2 $(A_{st})_{bldg} / (A_{st})_{proj} = 0.05$
- Block H : B-Score = 67.2 $(A_{st})_{bldg} / (A_{st})_{proj} = 0.17$

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

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

= **78**

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 the 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, to bring about greater productivity improvements, it is necessary to also tackle improvements in the downstream construction methods. 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 impacts 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 adopt the most cost-effective solution to meet the constructability requirement. The cconstructability 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 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 greater 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 at productivity improvements in 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, systems and use of advanced plant and equipment that are able to reduce manpower usage and improve site productivity are also awarded with points. The points are totalled 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, with 50 points given to the AMEP component and the remaining 10 points to the component on good 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 such as pre-insulated pipework and prefabricated ducts, as these are labour intensive trades. Similarly, Good Industry Practices focuses on specific good practices such as the use of Building Information Modeling (BIM) and productivity monitoring on site to achieve higher productivity.

1.4.4 The allocation of points to the Structural component, the AMEP component and 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. The points allocated to different formwork systems which are classified into various bands are given in Table 1 and 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 innovation items 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 / blockwall 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 ducts, flexible water pipes and mechanical joints, 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, systems, processes and plant and equipment 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 25 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 50 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 10 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 Methods, Systems, Processes, Plant & Equipment (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)	3	Points will be given once used
(d) Strut free deep basement construction[2]	4 (max)	Applicable for projects with restricted site access. Normal earth slope with or without concrete lining is excluded.
(e) Any other innovative methods, systems, processes, plant & equipment	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 method, system, process, plant & equipment 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 methods, systems, processes, plant & equipment with their respective point allocation.

(b) Different system formwork have varying efficiencies in terms of productivity performance. To determine the productivity of each system formwork, BCA will carry out a productivity assessment exercise 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 Methods, Systems, Processes, Plant & Equipment. 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.

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

ARCHITECTURAL, MECHANICAL, ELECTRICAL & PLUMBING SYSTEM (AMEP) (MAXIMUM 50 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[1] 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 Methods, Systems, Processes, Plant & Equipment (Maximum 25 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) Use of scissor lift and/or personnel lift in lieu of traditional scaffold for AMEP works	2	Points will be given once used
(d) Use of boom lift in lieu of traditional scaffold for AMEP works	2	Points will be given once used
(e) Any other innovative methods, systems, processes, plant & equipment	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 method, system, process, plant & equipment 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 methods, systems, processes, plant & equipment 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 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 Methods, Systems, Processes, Plant & Equipment. 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.

Table 3 Good Industry Practices

GOOD INDUSTRY PRACTICES (MAXIMUM 10 POINTS)	
Description	**Allocated Points**
(a) To use Building Information Modelling (BIM) for whole project duration to: (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	5
(b) To 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
(c) To 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
(d) To conduct monthly work study sessions, to scrutinise and improve the work process on site, as well as minimising wastage and improve productivity	2
(e) To use tools like CCTV to conduct real time monitoring on site to study resource flow, schedule and work process flow	2
(f) To 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

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 the practices throughout the duration of the project.

(b) Trade productivity has to be monitored on regular basis by the builder. A minimum of 5 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.

3 EXAMPLES ON COMPUTING CONSTRUCTABILITY SCORE

3.1 A residential non-landed development with 2 basements and GFA ≥ 25,000 m^2 (development is on land sold under Government Land Sales Programme after 1st Nov 2014)

<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 rowspan="2">$14 \times \frac{4000}{4000+2500}$

$15 \times \frac{2500}{4000+2500}$</td><td>8.62

5.77</td></tr>
<tr><td>Precast Columns (15 points)</td><td>2,500</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 methods, systems, processes, plant & equipment (max 15 points)</td><td>- Strut free deep basement construction</td><td>4</td></tr>
<tr><td colspan="2">Sub-total for A (max 60 points)</td><td><u>46.39</u>
<u>≥ 42 (min)</u></td></tr>
</table>

Construction Technologies / Practices	Computation	Score
Architectural, Mechanical, Electrical & Plumbing System (AMEP) (Max 50 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 20,000m^2* • *Floor area with screed (excluding wet areas) is 8,000m^2* Total floor area = 20,000 + 8,000 = 28,000m^2 **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
3. AMEP innovative methods, systems, processes, plant & equipment (max 25 points)	• *Use of scissor lift in lieu of traditional scaffold for MEP installation*	2
	Sub-total for B (max 50 points)	**11.57**
C. Good Industry Practices (Max 10 points)		
To 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
To 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
To conduct monthly work study sessions, to scrutinise and improve the work process on site, as well as minimising wastage and improve productivity		2
To 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 10 points)	**7**
Total Constructability Score = Sub-total (A) + Sub-total (B) + Sub-total (C)		**65** **> 57 (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**