CODE OF PRACTICE ON

Buildable Design

January 2004

Building and Construction Authority

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CODE OF PRACTICE

ANNEX

Introduction

The progressive tightening on supply of foreign workers and increasing demand for better quality make it necessary for the industry to adopt labour-efficient designs and use of more pre-assembled products. A key measure to achieve this is the introduction of government regulations under the Building Control Act to require building designs to have a minimum Buildability Score.

This Code sets out the requirements of minimum buildability and the submission procedures. It also sets out the method of determining the Buildability Score. 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 of Practice sets out the minimum Buildability Scores for different categories of building, the submission procedures and the method for determining the Buildability Score of a building design.

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.
Buildability Score	The score for buildability computed in accordance with Buildable Design Appraisal System as set out in the Code of Practice.
Minimum Buildability Score	The lowest Buildability Score allowed under a particular category of development stipulated in this Code.
Gross Floor Area	The gross floor area is calculated using the definition by the Urban Redevelopment Authority (URA).
Labour Saving Index	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. A labour saving index is also given for the use of prefabricated reinforcement/cages in cast in-situ components.
Qualified Person (QP)	The Qualified Person shall be as defined in the Building Control Act, Chapter 29, Part I, Section 2.

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 (Buildable Design) Regulations.

3.2 Responsibility

3.2.1 It is the responsibility of the owners, architects, engineers, contractors and others engaged in the design and construction of buildings to be conversant with the statutory requirements pertaining to Buildability Score. Designers should familiarise themselves with the Buildable Design Appraisal System (BDAS). This will enable them to consider a wider range of construction systems and products to meet the requirement for minimum buildability.

3.2.2 The owner shall engage the appropriate qualified persons to carry out buildable design. The QP for building works and the QP for structural works shall be responsible for ensuring that the buildability requirement is met. The QPs shall jointly declare the Buildability Score achieved. The QPs shall also jointly declare the As-built Buildability Score achieved.

4 BUILDABILITY SCORE REQUIREMENTS

4.1 Buildability Score

4.1.1 The Buildability Score of the building design shall be determined using this Code of Practice and the 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.

4.1.2 Summary of the three areas of scoring
The Buildability Score of a project is made up of 3 parts:

Part 1 – Structural System (maximum 50 points). Points are awarded for various types of structural system used.

Part 2 – Wall System (maximum 40 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 3 if a project uses single integrated components such as prefabricated bathroom/toilet units and precast household shelters.

The maximum buildability score achievable for a project is capped at 100 points.

4.2 Types of Development

4.2.1 The minimum Buildability Score requirement shall apply to all new residential, commercial, industrial and institutional buildings and other projects with Gross Floor Area (GFA) equals to or greater than 2,000 m^2. In addition, mixed development with GFA equals to or greater than 2,000 m^2 will also be subjected to legislation. New extension or addition to existing buildings shall also be subjected to the requirements of minimum Buildability Score if the GFA of the new extension or addition equals to or exceeds 2,000 m^2. The various types of building development are categorised in Table A. Buildings listed under the First Schedule are exempted from the buildability requirement.

4.2.2 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 Buildability Score requirement shall not be applicable.

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
Commercial	• Bank • Departmental store • Shopping centre • Office building • Supermarket • Restaurant • Hotel • Conventional hall and facilities • Exhibition hall

Table A Categories of Building *(cont'd)*

CATEGORIES	TYPES OF DEVELOPMENT
Industrial	• Factory • Warehouse • Godown • Brewery • Cold storage building • Packaging and processing plant • Printing plant • Sub-station
Institutional and others	• Library • Hospital • Home for the aged • Childcare centre/Nursery • Research building • Educational facilities • Terminal building • Campus • Medical centre • Camps • Embassy • Museum • Crematorium and Columbarium • Club house • Cinema/Theatre • Sports/Recreational facilities • Public transport stations

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

4.2.3 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.

4.3 Minimum Buildability Score

4.3.1 The minimum Buildability Score has been derived taking into account the average Buildability Scores achieved by the industry for different categories of building. The minimum Buildability Score for each category of development, namely residential projects, commercial projects, industrial projects and institutional and other projects are tabulated in Table B. Different minimum Buildability Score requirements are given for 2,000 $m^2 \leq$ GFA $<$ 5,000 m^2, 5,000 $m^2 \leq$ GFA $<$ 25,000 m^2 and GFA $\geq$ 25,000 m^2.

Table B Minimum Buildability Score

CATEGORY OF BUILDING/ DEVELOPMENT	MINIMUM BUILDABILITY SCORE		
	2,000 $m^2 \leq$ GFA $<$ 5,000 m^2	5,000 $m^2 \leq$ GFA $<$ 25,000 m^2	GFA $\geq$ 25,000 m^2
Residential (landed)	54	56	59
Residential (non-landed)	60	62	65
Commercial	62	69	72
Industrial	64	71	74
Institutional and others	60	66	69

4.3.2 For building works with applications for planning permission made on or after 1st January 2001 but before 1st August 2002, the minimum buildability scores stipulated in the Code of Practice on Buildable Design December 2000 still apply. Similarly, for building works with applications for planning permission made on or after 1st August 2002 but before 1st January 2004, the minimum buildability scores stipulated in the Code of Practice on Buildable Design June 2002 will also still apply. The table below illustrates which Code of Practice to be used depending on the date of application for planning permission of the building works.

Date of planning application	**Code of Practice on Buildable Design to be used**
Before 1st January 2001	Not applicable
1st January 2001 - 31st July 2002	December 2000 issue
1st August 2002 - 31st December 2003	June 2002 issue
On or after 1st January 2004	January 2004 issue

4.3.3 Minimum Buildability Score for Mixed Development

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

Computation of Buildability Score for a Mixed Development with GFA between 5,000 m² and 25,000 m²

CATEGORY OF BUILDING	**% OF BUILDING GFA**	**MINIMUM BUILDABILITY SCORE**
		5,000 m² ≤ GFA < 25,000 m²
Residential (non-landed)	70% of GFA	70% of 62 = 43.40
Commercial	30% of GFA	30% of 69 = 20.70
The required minimum Buildability Score	100% of GFA	**64 (rounded to nearest integer)**

Computation of Buildability Score for a Mixed Development with GFA 25,000 m² and above

CATEGORY OF BUILDING	% OF BUILDING GFA	MINIMUM BUILDABILITY SCORE
		GFA ≥ 25,000 m²
Residential (non-landed)	70% of GFA	70% of 65 = 45.50
Commercial	30% of GFA	30% of 72 = 21.60
The required minimum Buildability Score	100% of GFA	**67 (rounded to nearest integer)**

5 SUBMISSION PROCEDURES FOR BUILDABILITY SCORE REQUIREMENT

Buildability score will be one of the requirements for Building Plan (BP) approval. The BP will not be approved if the submitted buildability score is lower than the stipulated minimum. The buildability score is 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

5.1 Submission at BP Stage

The QPs shall indicate in Form BPD_BP03 (Application for Approval of Building Plans) whether Buildability Score calculations are applicable to the proposed building works. If applicable, the Buildability Score is to be submitted together with the BP submission using Form BPD_BS01. The Buildability Score is to be jointly declared by all QPs and the detailed computation of the Buildability Score attached. Forms BPD_BP03 and BPD_BS01 can be downloaded from BCA's website at http://www.bca.gov.sg/.

5.2 Submission at ST Superstructural Stage

The current submission procedures allow the ST to be submitted separately from the BP. The structural buildability score is required to be submitted at the ST superstructural stage, if applicable. For each ST submission **before** BP submission, the QPs shall indicate in Form BEV/A1 (Application for Approval of Structural Plans) whether Buildability Score calculations are applicable to the proposed building works. If applicable, the Structural Buildability Score is to be submitted by the QP for Structural Works using Form BEV/A1_BS02. Forms BEV/A1 and BEV/A1_BS02 can be downloaded from BCA's website at http://www.bca.gov.sg/.

5.3 Submission at TOP/CSC stage

5.3.1 Upon project completion, the QPs shall compute and declare the As-built Buildability Score and submit one set of the computation to BCA using Form BPD_BS03. This application is to be made within one month of obtaining TOP or before CSC, whichever is earlier. Form BPD_BS03 can be downloaded from BCA's website at http://www.bca.gov.sg/.

5.3.2 BCA may conduct site checks during the construction stage.

First Schedule

BUILDING WORKS WHICH ARE NOT SUBJECTED TO THE MINIMUM BUILDABILITY REQUIREMENT

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

Contents

1.0 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 'Buildability Score' of the design. A design with a higher buildability 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 buildability scores.

Neither is the BDAS intended to solely promote prefabrication. Although, in general, prefabrication should give higher buildability scores, designs using simple cast-in-place construction can also yield reasonably high buildability 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 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. Precast concrete external walls, curtain walls or prefabricated toilets 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 system and the major architectural components such as external and internal walls, 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 "Buildability Score" of the design.

1.4 Buildability Score and Contractor's Productivity

The particular Buildability 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 Buildability Score will imply that the same contractor should build that project with less site labour than one with a low Buildability Score.

1.5 Rationale on Allocation of Points

The computation of Buildability Score for a project involves the summation of Buildability Score attained for structural systems, wall systems and other buildable features. The maximum Buildability 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 indices (LSIs). A labour saving index (LSI) is given to each building system and for 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. Labour productivity, measured in square meter 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. A high index indicates that the design is more buildable and fewer site workers are needed.

1.7 Updates

This Code of Practice on Buildable Design, January 2004, has included a number of updates.

1.7.1 Allocation of Buildability Points

The key changes are listed below:

(a) The maximum buildability point for wall systems has been revised from 30 to 40 points.

(b) The maximum buildability point for the use of other buildable design features has been revised from 20 to 10 points.

(c) Bonus points are given for the use of single integrated components such as prefabricated bathroom/toilet units and precast household shelters.

1.7.2 Structural System

The key changes are listed below:

(a) The structural systems have been regrouped into 4 main headings, namely precast concrete system, structural steel system, cast in-situ system and roof system.

(b) Metal roof on cast in-situ beam has been included under roof system.

(c) The use of transfer beam would result in a deduction of buildability points due to its negative impact.

(d) The use of prefabricated reinforcement/cages in cast in-situ floor, beam and column would be given points under this section.

1.7.3 Wall System

The key changes are listed below:

(a) The labour saving indices have been regrouped. Two indices are given for all wall systems except brickwall and external wall using precision blocks. The higher index is given if the wall has no finishes, the finishes are done off-site or where only skim coat and/or paint is applied on site. Conversely, the lower index is allocated for the use of on-site plastering, tiling or stone finishes.

(b) The use of prefabricated reinforcement in cast in-situ wall would be given points under this section.

(c) The method for computing the buildability score of wall systems has been revised. The length of wall instead of the wall area is now used to compute the wall score. Windows and doors are also excluded from the computation, except when full height windows or doors are used.

1.7.4 Other Buildable Design Features

The key changes are listed below:

(a) Table 3A on Standard Door Leaf Openings and Structural Openings has been removed. Instead, points would be awarded for standardisation of door leaf openings in 0.5M module.

(b) Repetition of horizontal grids has been removed.

(c) Clarification on consideration for repetition of floor-to-floor height and vertical repetition of structural floor layout has been provided. In both cases, the bottom floor, top floor and above should be omitted from the consideration for repetition. Different point allocation has been given for blocks up to 6 storey and blocks more than 6 storey high. For blocks up to 6 storey, points would only be given if there are at least 2 floors / floor heights remaining after the floor omission.

(d) The use of prefabricated reinforcement/cages in cast in-situ floor, wall, beam and column has been incorporated under Table 1 on structural systems and Table 2 on wall systems.

(e) Table 3B on Standard Precast Staircase Size has been removed. Points would be awarded for the use of precast staircase, irrespective of the dimensions of riser and tread.

(f) "Prefabricated vertical shafts (e.g. refuse chute)" has been reworded to "Precast refuse chutes". The prescribed dimensions for fully precast refuse chutes have been removed.

(g) "Precast meter chambers" and "Precast service risers" have been added as buildable design features.

(h) "Ground beams on top of pilecaps" has been reworded to "Ground beams on top of pilecaps and/or integrated with pilecaps".

(i) Diaphragm wall construction has been removed.

(j) Bonus points would be awarded for the use of prefabricated bathroom/toilet units and precast household shelters.

1.8 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.

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

2.1 Components of the Appraisal System

The BDAS provides a method to compute the Buildability Score of a design. It consists of three main parts:

(a) the Structural System;
(b) the Wall System; and
(c) Other Buildable Design Features.

Buildability 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 Buildability Score for a particular structural system is the product of the percentage areas covered by the structural system and the corresponding labour saving indices available in Table 1. These are summed up and multiplied by the weight factor to arrive at the Buildability Score of the total structural system. The maximum Buildability Score is 50 points.

Buildability Score of the Wall System

The Buildability Score for a particular wall system is computed by multiplying the percentage wall length covered by the wall systems and the corresponding labour saving indices. These are summed up and multiplied by the weight factor to arrive at the Buildability Score of the total wall system. The maximum Buildability Score achievable in Table 2 is 40 points.

Buildability Score of Other Buildable Design Features

In this section, the buildability of the design is examined at the detailed level. Three basic design characteristics, namely standardisation of columns, beams, windows and doors, grids and usage of precast components are considered. The use of these buildable design features will be awarded with points directly. The maximum Buildability Score that can be achieved in this section is 10 points. In addition, bonus points would be given for the use of single integrated components such as prefabricated bathroom/toilet units and precast household shelters.

2.2 Computation of Buildability Score

The Buildability Score formula is expressed as:

Buildability Score of Building	=	Buildability Score of Structural System (including Roof System) + Buildability Score of Wall System + Buildability Score of Other Buildable Design Features
BS	=	$50[\sum(A_s x S_s)] + 40[\sum(L_w x S_w)] + N$ + 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 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)
S_w	=	Labour saving index for external & internal wall system (Table 2)
N	=	Buildability Score for other buildable design features (Table 3)
Bonus points	=	Bonus points for the use of single integrated components

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

BS project = Sum of [BS building x (A_{st}) building / (A_{st}) project]

EXPLANATORY NOTES TO BUILDABILITY SCORE FORMULA

(a) Buildability Score of Structural System

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

Method for computation $50[\sum(A_S x S_S)]$

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

S_S : A labour saving index for the particular structural system. The labour saving indices for the various structural systems are given in Table 1.

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 maximum Buildability Score for the structural system is 50 points.

The total floor area is the total floor area constructed in the project, and includes roof (projected area) and basement area.

(b) Buildability Score of Wall System

The score for the wall system is based on:

Method for computation $40[\sum(L_W x S_W)]$

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.

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 maximum Buildability Score for the wall system is 40 points.

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

(c) Buildability 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) Buildability Score of Single Integrated Components, Bonus points

Bonus points are given for the use of single integrated components such as prefabricated bathroom/toilet units and precast household shelters. The points of various single integrated components are given in Table 3.

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 with flat plate/flat slab[1]	0.95
	Precast beam and precast slab	0.90
	Precast beam and precast column/wall	0.85
	Precast column/wall and precast slab	0.80
	Precast beam only	0.75
	Precast slab only	0.75
	Precast column/wall only[1]	0.75
Structural Steel System (applicable only if steel decking or precast slab is adopted)	Steel beam and steel column (without concrete encasement)	0.95
	Steel beam and steel column (with concrete encasement)	0.85
Cast In-situ System	Flat plate[1]	0.90
	Flat slab[1]	0.85
	One-way banded beam[1]	0.75
	Two-way beam[1] (slab/beam[2] >10)	0.65
	Two-way beam[1] (slab/beam[2] $\leq$10)	0.50
Roof System	Integrated metal roof on steel truss	0.90
	Metal roof on steel truss or timber truss	0.85
	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) For cast in-situ floor with cast in-situ transfer beam, an index of -0.10 shall be applied to the entire cast in-situ floor area. This requirement does not apply to cast in-situ floor with transfer beam designed for ramp access.

(2) Slab/beam refers to the value of slab area over number of beams.

* An index of 0.03 each would be given if prefabricated reinforcement/cage is used in cast in-situ slab, 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.

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) For cast in-situ beam and slab construction, the slab/beam value is calculated by dividing the floor slab area over the number of beams supporting that floor area. A continuous beam across three columns is considered as two beams for the purpose of determining the value of slab area over number of beams. Similarly, a continuous beam across four columns is considered as three beams.

(d) Flat plate refers to a slab design which does not have column heads or drop panels.

(e) The index for concrete roof depends on the type of structural system used and follows the respective index given under cast in-situ system.

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

(g) A transfer beam refers to a beam that interrupts the paths of load bearing elements from above and distributes the loads sideways to the ends of the beams.

(h) Additional points in the form of labour saving index of 0.03 each would be awarded for the use of prefabricated reinforcement/cages in cast in-situ floor, beam and column.

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.

Example of prefabricated reinforcement:

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 = 0.03 x 0.70 x 50

= 1.05

TABLE 2 Wall Systems - S_W Value

WALL SYSTEM	LABOUR SAVING INDEX S_W	
Curtain wall/full height glass partition/dry partition wall[2]/ prefabricated railing	0.70	1.00[1]
Precast concrete panel/wall[3]	0.80	0.90[1]
PC formwork[4]	0.50	0.75[1]
Cast in-situ RC wall	0.50	0.70[1]
Cast in-situ RC wall with prefabricated reinforcement	0.54	0.74[1]
Precision block wall (internal wall)	0.40	0.45[1]
Precision block wall (external wall)	0.30	
Brickwall	0.30	

NOTE:

(1) The higher indices apply to no finishes, finishes done off-site or where skim coat and/or paint is applied on site.

(2) Dry partition walls include sandwich panel wall systems, stud and sheet partition wall systems, demountable wall systems.

(3) Precast concrete panels/walls include normal weight concrete panels, lightweight concrete panels, autoclaved aerated concrete panels.

(4) PC formwork refers to precast formwork panel with concrete infill.

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

EXPLANATORY NOTES TO TABLE 2

(a) Table 2 has been arranged into the various wall systems with their respective labour saving indices. Where a wall system has 2 labour saving indices, the lower index is applicable when the finishes involve plastering, tiling or stone works on site. Conversely, the higher index applies when there are no finishes, the finishes are done off-site or the finishes only involve application of skim coat and/or paint on site. 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) Dry partitions refer to panels that do not require the use of water for erection. Examples are solid composite gypsum boards, cementitious panels or glass panels etc. Precision blocks refer to lightweight concrete blocks that have precised dimensions (± 1mm dimensional tolerance) and can be laid on thin bed adhesive mortar.

(c) The use of prefabricated reinforcement in cast in-situ walls must be indicated on plans.

TABLE 3 Other Buildable Design Features - N Value

BUILDABLE FEATURES		MODULE	UNIT OF COVERAGE	N VALUE	
				PERCENTAGE OF COVERAGE[4]	
				≥65% TO < 80%	≥80%
1. Standardisation					
1.1	Columns (3 most common sizes)	0.5M[2]	no.		2.00
1.2	Beams (3 most common sizes)	0.5M[2]	no.		2.00
1.3	Door leaf openings (width) (3 most common sizes)	0.5M	no.		1.00
1.4	Windows (3 most common sizes)[1]	1M/1M[3]	no.		1.00
2. Grids					
2.1(a)	Repetition of floor-to-floor height For blocks more than 6 storey *The repetition should omit bottom floor, top floor and above.*	0.5M	no.	1.50	2.00
2.1(b)	Repetition of floor-to-floor height For blocks up to 6 storey *The repetition should 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
2.2(a)	Vertical repetition of structural floor layout For blocks more than 6 storey *The repetition should omit bottom floor, top floor and and above.*		area	1.50	2.00
2.2(b)	Vertical repetition of structural floor layout For blocks up to 6 storey *The repetition should 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. Others					
3.1	Multi-tier precast columns		no.		2.00
3.2	Precast or pre-assembled/metal staircases		no.		2.00
3.3	Precast meter chambers		no.		1.50
3.4	Precast refuse chutes		no.		1.50
3.5	Precast service risers		no.		1.00
3.6	Non-screed floor		area		1.00
3.7	Columns sit directly on top of piles		no.		1.00
3.8	Ground beams on top of pilecaps and/or integrated with pilecaps		no.		1.00
A. Single Integrated Components (Bonus Points)					
A.1	Prefabricated bathroom/toilet units complete with piping/wiring		no.	2.00	3.00
A.2	Precast household shelters *Household shelter is considered as precast if the total length of the in-situ joints is not more than 20% of its wall perimeter on plan.*		no.	2.00	3.00

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.

EXPLANATORY NOTES TO TABLE 3

(a) Table 3 shows the point given to each buildable design feature that contributes to labour saving on site. Points are summed up to form the Buildability Score for this section. The maximum score for this section is 10 points.

(b) For item 1 – 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.

(c) For item 2 – Grids, the criteria of minimum module (where applicable) 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.

(d) 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".

(e) The percentage of coverage for each type of design feature is classified into 2 categories:
   (i) $\geq$ 65% to < 80%
   (ii) $\geq$ 80%

(f) BCA shall determine the points to be awarded or not to be awarded for other buildable design 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.

3.0 EXAMPLES ON COMPUTING BUILDABILITY SCORE

3.1 A SINGLE BLOCK BUILDING PROJECT

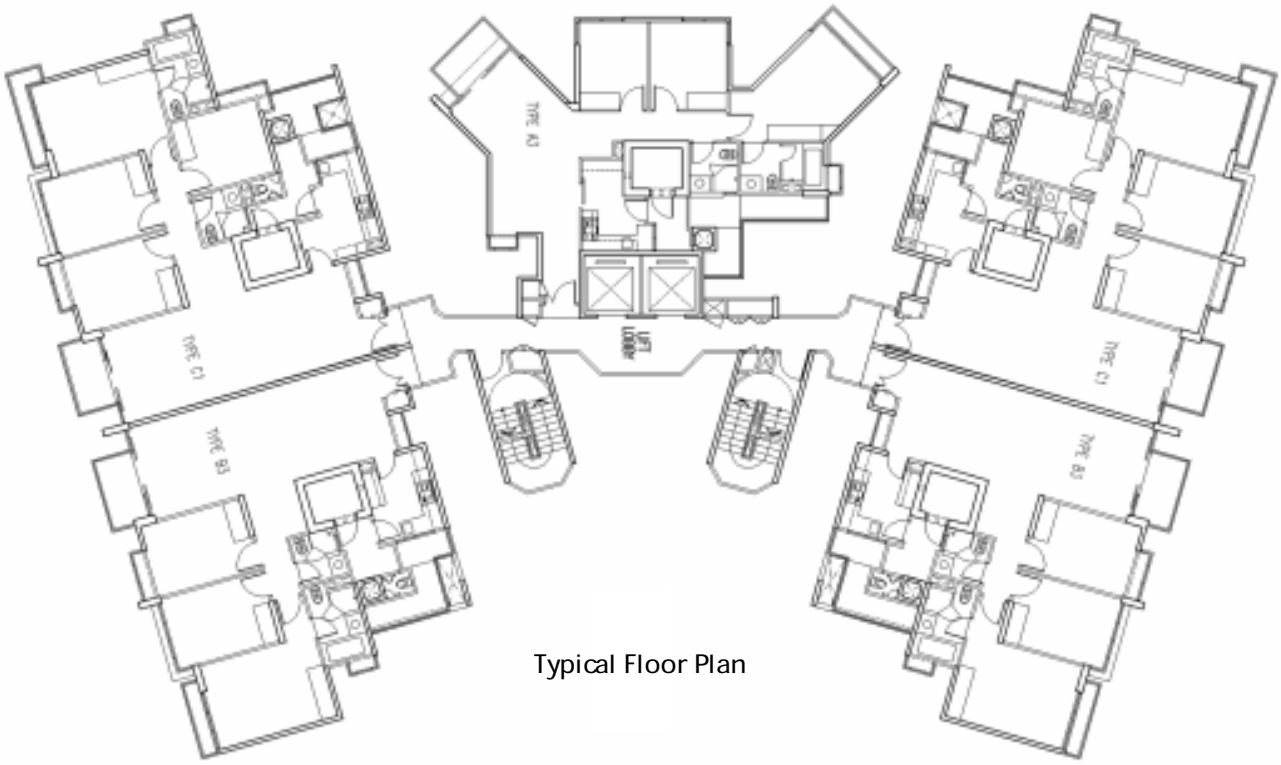
A. Project Information

- 1 block of 18-storey high residential flat
- No basement
- 5 residential units per storey
- For simplicity, assume typical floor layout for each floor
- Assume floor-to-floor height of 3.3m, except 1st storey, which is 4m high
- For area of building:

Total floor area of residential units	=	18 x 645.90m^2	11,626.20m^2
Total floor area of Lift Lobby	=	18 x 102.40m^2	1,843.20m^2
Roof area (assume same as typical floor)			748.30m^2
Ast : Total floor area of building induding roof area			14,217.70m^2

B. Buildability Score Formula

$BS = 50[\sum(A_S \times S_S)] + 40[\sum(L_W \times S_W)] + N + \text{Bonus Points}$



Typical Floor Plan

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 precision blocks.

DESCRIPTION	LABOUR SAVING INDEX	AREA (m^2) or LENGTH (m)	COVERAGE (%)	BUILDABILITY SCORE
Structural System				
(1) Flat plate for apartment area + Roof A_{sa} = 19 x 645.90 = 12,272.10m^2 A_{st} = 14,217.70m^2	S_S = 0.90	12,272.10m^2	86.32%	38.84
(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 Value of slab area over number of beams less than 10	S_S = 0.50	1,945.60m^2	13.68%	3.42
Note : - Roof design as in (1) and (2)				
Total		14,217.70m^2	100.00%	42.26
Use of prefabricated reinforcement Welded mesh for cast in-situ floor slab 86% of total floor area	0.03		86.00%	1.29
Total (a)				**43.55**
Wall System				
(1) Full height glass and railing	S_W = 1.00	408.60m	3.86%	1.55
(2) Curtain wall	S_W = 1.00	717.30m	6.78%	2.71
(3) Precast concrete wall - skim coat and paint finish	S_W = 0.90	5,204.20m	49.22%	17.72
(4) Cast in-situ RC wall (staircase and lift shaft) - plaster & paint finish	S_W = 0.50	885.00m	8.37%	1.67
(5) Precision blocks - skim coat and paint finish (internal wall)	S_W = 0.45	1,963.90m	18.58%	3.34
(6) Precision blocks - tiled finish (internal wall)	S_W = 0.40	313.60m	2.97%	0.47
(7) Precision blocks - skim coat and paint finish (external wall)	S_W = 0.30	1,080.20m	10.22%	1.23
Total (b)		10,572.80m	100.00%	**28.69**

DESCRIPTION	LABOUR SAVING INDEX	AREA (m^2) or LENGTH (m)	COVERAGE (%)	BUILDABILITY SCORE
Other Buildable Design Features				
(1) Standardisation of columns (0.5M) 3S at 86%			86%	N = 2.00
(2) Standardisation of door leaf openings (width) (0.5M) 3S at 85%			85%	N = 1.00
(3) Standardisation of windows (1M/1M) 3S at 85%			85%	N = 1.00
(4) Repetition of floor-to-floor height (0.5M) 100%			100%	N = 2.00
(5) Precast refuse chutes 100%			100%	N = 1.50
(6) Ground beams on top of pilecaps 85%			85%	N = 1.00
Total (c)				**8.50**
Buildability Score of Project (a) + (b) + (c)				**81**

3.2 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} = 2,700m^2 per building
- Block D A_{st} = 3,000m^2
- Block E A_{st} = 2,400m^2
- Block F A_{st} = 2,600m^2
- Block G A_{st} = 1,000m^2
- Block H A_{st} = 3,600m^2

  Overall project A_{st} = 20,700m^2

B. Buildability Score

The Buildability Score (BS) for the respective blocks is as follows:

- Block A : BS = 79.0 $(A_{st})_{bldg} / (A_{st})_{proj}$ = 0.13
- Block B : BS = 79.0 $(A_{st})_{bldg} / (A_{st})_{proj}$ = 0.13
- Block C : BS = 79.0 $(A_{st})_{bldg} / (A_{st})_{proj}$ = 0.13
- Block D : BS = 79.0 $(A_{st})_{bldg} / (A_{st})_{proj}$ = 0.14
- Block E : BS = 79.0 $(A_{st})_{bldg} / (A_{st})_{proj}$ = 0.12
- Block F : BS = 77.0 $(A_{st})_{bldg} / (A_{st})_{proj}$ = 0.13
- Block G : BS = 59.2 $(A_{st})_{bldg} / (A_{st})_{proj}$ = 0.05
- Block H : BS = 57.2 $(A_{st})_{bldg} / (A_{st})_{proj}$ = 0.17

The Buildability Score of the project is computed as below:

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

= 74