STANDARD INDUSTRI PEMBINAAN

(CONSTRUCTION INDUSTRY STANDARD)

CIS 30:2021

PRODUCTIVITY MEASUREMENT OF BUILDING CONSTRUCTION PROJECTS

Description: productivity, construction projects, productivity score, productivity grade, productivity measurement

CONSTRUCTION INDUSTRY DEVELOPMENT BOARD

Construction Industry Development Board Malaysia

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CIDB MALAYSIA

CIS 30: 2021 Productivity Measurement of Building Construction Projects

e-ISBN 978-967-2971-39-9

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Perpustakaan Negara Malaysia Cataloguing-in-Publication Data

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COMMITTEE REPRESENTATION

This Construction Industry Standard (CIS) was developed and reviewed by the Construction Industry Development Board (CIDB) Malaysia with the assistance from the Technical Committee on Productivity Measurement of Building Construction Projects, which comprises representatives from the following organisations:

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Jabatan Perumahan Negara

Malaysia Productivity Corporation

Department of Statistics Malaysia

Universiti Tun Hussein Onn Malaysia

Universiti Teknologi MARA

National University of Singapore

Universiti Tunku Abdul Rahman

Construction Research Institute of Malaysia

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Persatuan Arkitek Malaysia

Master Builder Association Malaysia

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BIM Engineering Solution & Technology Sdn. Bhd.

PC Forging Malaysia Sdn. Bhd.

MRCB Building Systems

PREFACE

This Construction Industry Standard (CIS) is referred as CIS 30: 2021. It was developed as a Productivity Measurement of Building Construction Projects by the Construction Industry Development Board (CIDB) Malaysia. This standard will serve as a baseline for measuring productivity in a building construction in Malaysia. This document is the continuation of the previous study derived on the Productivity Measurement Tools (PMT) for building construction. This document involves the productivity of labour, defined as real output per labour day. The documentation of the standard was carried out by a Technical Committee formed by CIDB, whose members were the representatives of the industry's stakeholders.

Several documents generally used by industry were made as references related to the productivity in the building projects as listed in Section 1 of the CIS 30:2021. This standard is subject to productivity studies based on constructed Gross Floor Area, total manpower and the total duration of the construction projects.

It should be noted that compliance to this Construction Industry Standard does not in itself confer immunity from legal obligations.

PRODUCTIVITY MEASUREMENT OF BUILDING CONSTRUCTION PROJECTS

SECTION 1: GENERAL

1.1 Introduction

Productivity Measurement of Building Construction Projects is a tool to assess and measure the level of productivity of a building construction. The measurement is based on the constructed Gross Floor Area (GFA), duration of the project (days) and total of manpower from design until the issuance of Certificate of Practical Completion (CPC). The measurement takes into consideration Mechanical, Electrical & Plumbing (MEP) works as well as Civil, Structural and Architectural (CSA) works. The measurement is divided into two sections which are project based and site based.

1.2 Objectives of Productivity Measurement of Building Construction Projects

Productivity Measurement of Building Construction Projects was designed and developed to enable the user to achieve any, or a combination of, the following objectives:

(i) To establish a standard system on productivity measurement of building construction projects

(ii) To act as a reference and baseline standard for the purpose of measuring productivity performance of building construction projects

(iii) To evaluate the performance of building construction projects in terms of productivity at project and site level.

1.3 Scope of Productivity Measurement of Building Construction Projects

This standard presents the productivity measurement of building construction projects using specific productivity measurement tools. The productivity measurement covers all construction lifecycle stages starting from design, production, logistic, installation and construction. To ensure a comprehensive measurement being made, the productivity measurements encompass two construction methods using conventional and Industrialised Building System (IBS). IBS consists of six types of building system: (1) precast concrete system, (2) metal framing system, (3) reusable formwork system, (4) blockwork system, (5) timber framing system, and (6) innovative system which includes Prefabricated Prefinished Volumetric Construction (PPVC).

The productivity measurement tool focuses on building construction projects including roofing system, which excludes the infrastructure construction projects to be assessed. There are three main components in the measurement tool namely, total Constructed Gross Floor Area (GFA), number of manpower and total time of construction period. Table 1 shows the construction work stages and its presence of manpower in each scope, respectively. Note that PMT has taken into consideration the number of manpower involved in MEP and CSA works as shown in the following tables (Table 1 and Table 2). This document comprises two sections involving project-based and site-based construction. The measurement of productivity for project-based construction will include the design, production, logistics, installation and construction stages while site-based construction only measures the installation and construction stages.

The measurement of productivity rate for building construction projects also implements a grading system which is used to rank the productivity performances throughout the construction projects. This grading system shall indicate the level of productivity rates for building construction projects in Malaysia. Please note that, for more accurate measurement of productivity performance, data collection should begin immediately upon site possession.

Table 1: Scope of PMT for The Purpose of Measuring Project-Based Productivity

Building Systems	PROJECT STAGES								
	Design (A)		Production (B)		Logistics (C)	Installation (D)		Construction (E)	
	CSA	MEP	CSA	MEP		CSA	MEP	CSA	MEP
	Manpower (man-day/sq. ft.)								
Precast Concrete	/	/	/	/	/	/	/	/	/
Metal Framing	/	/	/	/	/	/	/	/	/
Reusable Formwork	/	/	/	/	/	/	/	/	/
Blockwork	/	/	/	/	/	/	/	/	/
Timber Framing	/	/	/	/	/	/	/	/	/
Innovative	/	/	/	/	/	/	/	/	/
Prefabricated Prefinished Volumetric Construction (PPVC)	/	/	/	/	/	/	/	/	/
Conventional	/	/	/	/	/	/	/	/	/

Table 2: Scope of PMT for The Purpose of Measuring Site-Based Productivity

Building Systems	Construction Work Stages			
	Installation		Construction	
	CSA	MEP	CSA	MEP
	Manpower (man-day/sq. ft.)			
Precast Concrete	/	/	/	/
Metal Framing	/	/	/	/
Reusable Formwork	/	/	/	/
Blockwork	/	/	/	/
Timber Framing	/	/	/	/
Innovative	/	/	/	/
Prefabricated Prefinished Volumetric Construction (PPVC)	/	/	/	/
Conventional	/	/	/	/

1.4 Use of Productivity Measurement of Building Construction Projects

This measurement shall be used to evaluate the productivity of each building construction project as there is no significant method and measurement being identified specifically for construction industry. The application of the productivity measurement tools that covers the whole construction lifecycle stages shall be implemented by all stakeholders involved to ensure the establishment of a significant baseline on productivity rates in Malaysian construction industry.

1.5 Terms and Definitions

For the purpose of this standard, the following definition applies.

i. Productivity

Productivity is the ratio of output to input.

ii. Productivity Performance

Productivity performance in this context is defined as the ratio of total constructed Gross Floor Area (GFA) to the total man-days.

iii. Man-days

One man-day in this context is defined as one (1) manpower working for eight (8) hours per day. The site management team is excluded when calculating the total number of site workers.

iv. Man-hours

Man-hours in this context is the total hours regarded in term of the amount of work that can be done by one person within a specified period.

v. Grading System

Grading system in this standard is based on the scale of productivity score being achieved.

vi. Constructed Gross Floor Area (GFA)

Constructed Gross Floor Area (GFA) in building construction is defined as the total of all enclosed space fulfilling the functional requirements of the building measured to the internal face of enclosing walls which included measurable and quantifiable constructed floor or slab areas in building including:

i. all types of roof;
ii. car porch and podium;
iii. corridors, balconies and lobbies;
iv. lobby lifts, plant and tank rooms and the like above main roof slab; and
v. sloping surfaces such as staircases and the like but measured flat on plan

vii. Total Construction Duration

Total Construction Duration in this context involved the total number of days from the Design stage, Production stage, Logistics stage, Installation stage and Construction stage.

viii. Industrialised Building System (IBS)

IBS is a construction technique in which components are manufactured in a controlled environment (on or off site), transported, positioned, and assembled into a structure with minimal additional site work.

ix. Prefabricated Prefinished Volumetric Construction (PPVC)

Prefabricated Prefinished Volumetric Construction (PPVC) is a construction method whereby free-standing 3-dimensional modules are completed with internal finishes, fixtures and fittings in an off-site fabrication facility, before being delivered and installed on-site. PPVC consists of three (3) categories which are complete, semi-completed and carcass.

x. Conventional Construction

Conventional construction method is defined as construction works executed on site through the processes or timber or plywood formwork installation, steel reinforcement and cast in–situ concrete.

xi. Precast Concrete System

The common IBS used includes precast concrete elements, lightweight precast concrete and permanent concrete formwork.

xii. Metal Framing System

Commonly used with precast concrete slab, steel framing system has always been a popular choice and extensively used in fast-track construction of skyscrapers. The recent development of this IBS includes the use of light steel trusses that consist of cost efficient profiled cold formed channel and steel portal frame system. These are the alternatives to the heavier traditional hot rolled section.

xiii. Blockwork System

The construction method of using traditional bricks has been centralised by the development of interlocking concrete masonry units and lightweight concrete blocks. The tedious and time-consuming traditional bricklaying tasks are greatly simplified by the usage of these practical solutions.

xiv. Reusable Formwork System

Prefabricated formwork used for temporary shoring at site for the construction of in-situ walls and slabs.

xv. Timber Framing System

This system consists of timber building frames and timber roof trusses. Timber building frame system also has their market and demand, offering attractive designs ranging from simple dwelling units to buildings that require high aesthetical values such as resorts and chalets.

xvi. Innovative System

In order to classify new system introduced in the Malaysian construction industry that does not belong in the main five CIDB's IBS classifications, CIDB introduced innovative system to classify these new and innovative systems based on IBS approach.

xvii. Design Stage

This is the process of taking on and developing the approved concept design. Design stages include pre-design, schematic design, detailed design and shop drawing for architectural, structural and Mechanical and Electrical (M&E) drawing.

xviii. Production Stage

The process of manufacturing building components in a controlled environment.

xix. Logistic Stage

The process of delivering supply chain resources from the point of origin to the destination.

xx. Installation Stage

The process of lifting, installing, and assembling building components at construction site.

xxi. Construction Stage

The process of measuring building activities progress involving construction works at construction site. The measurement at construction stages should consider combining these factors such as skill of occupation, material, machines and technologies used.

xxii. Civil, Structural and Architectural (CSA) works

CSA is a type of building works involving any activities of civil, structural and architectural works in the whole construction stage lifecycle wherever applicable.

xxiii. Mechanical, Electrical and Plumbing (MEP) works

MEP is a type of building works which involved any activities for mechanical, electrical and plumbing works in the whole construction stage lifecycle wherever applicable.

xxiv. Site-Based Productivity

Measurement of productivity achieved at installation and construction stages.

xxv. Project-Based Productivity

Measurement of overall productivity achieved in design, production, logistic, installation and construction stages.

xxvi. Certificate of Practical Completion (CPC)

CPC is issued by the architect (Superintendent Officer (SO) to the main contractor when the architect is satisfied with all the physical works being completed in the building.

1.6 Categories of Buildings

Categories of buildings can be referred to as landed housing, stratified housing, public and commercial buildings with and without centralised cooling system. This standard is not applicable for aesthetic architectures such as mosques and museums. The exceptions are listed below in the table. This standard is only applicable for the following types of building as shown in Table 3**: Categories of Buildings**

Table 3: Categories of Buildings

CATEGORIES	TYPES OF BUILDING
Landed housing	• Detached house • Semi-detached house • Terrace house • Cluster house
Stratified housing	• Flats • Apartments • Service apartments • Condominiums • Town houses
Public/commercial/industrial buildings with and without centralised cooling system)	• Office buildings • Factories • Warehouses • Workshops • Small office flexible office (SOFO) • Small office virtual office (SOVO) • Small office home office (SOHO) • Community halls • Schools • Universities, colleges • Police stations • Departmental stores & Shopping centres • Supermarkets • Restaurants • Conventional halls and facilities • Exhibition halls • Educational facilities • Hotel • Amusement parks

NOTE: The exception from these buildings includes religious buildings, museum, stadium, hospital and airport terminal buildings.

SECTION 2: PRODUCTIVITY MEASURING TOOL (PMT)

Productivity Measuring Tool (PMT) measures two different types of productivity in building construction projects: project-based productivity and site-based productivity. Project productivity measures productivity of a project which considers total number of manpower involved in the project and total construction period, from design stage until CPC. Site productivity measures productivity of a project at construction site only, which considers total number of manpower and total working hours involved at construction site that includes installation and construction works.

2.1 Productivity Performance Equation

PMT defines productivity as the ratio of total constructed gross floor area to the total man-hours as shown in Equation 1.

Equation 1: Productivity Performance Equation

$$\text{Productivity Performance} = \frac{\text{Total constructed gross floor area (sq. ft.)}}{\text{Total man} - \text{days}}$$

*Total man-days = Total no of manpower x Total construction period (months) x working days/month

2.2 Productivity Grading System

The productivity grading system is used to rank the productivity performance based on the productivity measurement. Table 4 and Table 5 are the grading systems used in ranking the productivity performance in terms of sq. ft./man-day for project-based and site-based, respectively.

Table 4: Grading System Based on Project Productivity Performance in sq. ft./man-day

Grades	Project Productivity Performance, x (sq. ft. / man-days)	Description
A	x ≥ 10.0	Excellent construction productivity and very low manpower dependency
B	7.5 ≤ x < 10.0	High construction productivity and low manpower dependency
C	5.0 ≤ x < 7.5	Fair construction productivity and manpower dependency
D	2.5 ≤ x < 5.0	Low construction productivity and high manpower dependency
E	x < 2.5	Poor construction productivity and very high manpower dependency

Table 5: Grading System Based on Site Productivity Performance in sq. ft./man-day

Grades	Site Productivity Performance, x (sq. ft. / man-days)	Description
A	x ≥ 12.0	Excellent construction productivity and very low manpower dependency
B	9.0 ≤ x < 12.0	High construction productivity and low manpower dependency
C	6.0 ≤ x < 9.0	Fair construction productivity and manpower dependency
D	3.0 ≤ x < 6.0	Low construction productivity and high manpower dependency
E	x < 3.0	Poor construction productivity and very high manpower dependency

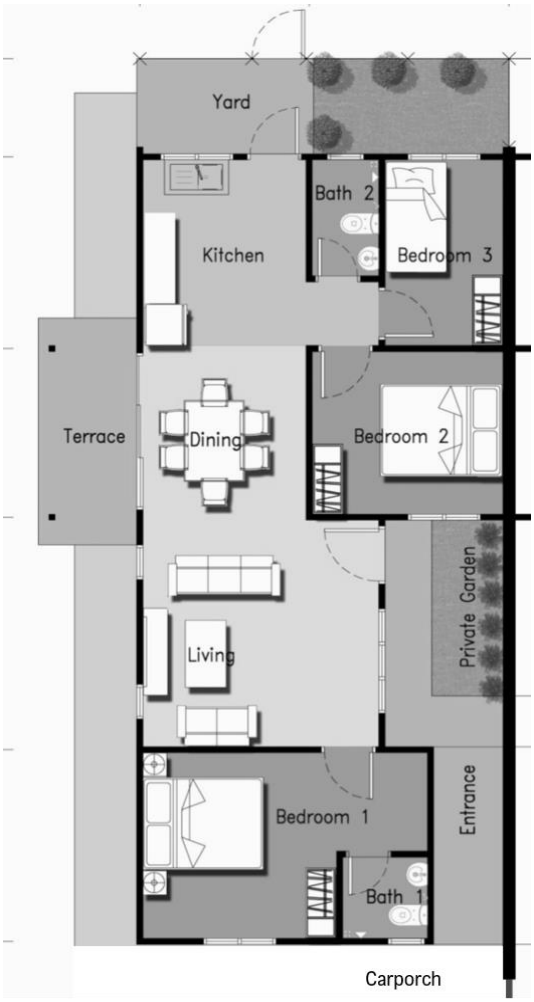
2.2.1 Productivity Grading System Calculations

The proposed grading system was developed by the researchers together with the industry players involved in the previous study. The main objective of the grading system is to grade the building construction projects through site-based productivity performance or project-based productivity performance. Based on literature review done for the study, it was found that the overall site labour productivity for public housing in Singapore was 1.0 m2 per man-day which is approximately equivalent to 10 sq. ft./ man-day. As Malaysia currently has no defined highest productivity rate in IBS projects to be used as a benchmark, 10 sq. ft/man-day was used as a reference.

In 2020, CIDB Malaysia and CREAM conducted a study to identify the difference in productivity performance between IBS and conventional construction method1. The productivity performances of 28 IBS projects and 28 conventional projects were analysed for site-based and project-based. From the study, it was found that site-based gained approximately 20% in productivity performance as compared to project-based productivity performance. Therefore, it was concluded that the reference of 10 sq. ft./man-day is to be increased by 20% and used as benchmark for site-based productivity performance in Malaysia. Therefore, the productivity performance for site-based project now stands at 12 sq. ft./man-day.

2.3 Constructed Gross Floor Area (GFA)

Figure 1: Shaded Area Shows the GFA for Landed House Unit

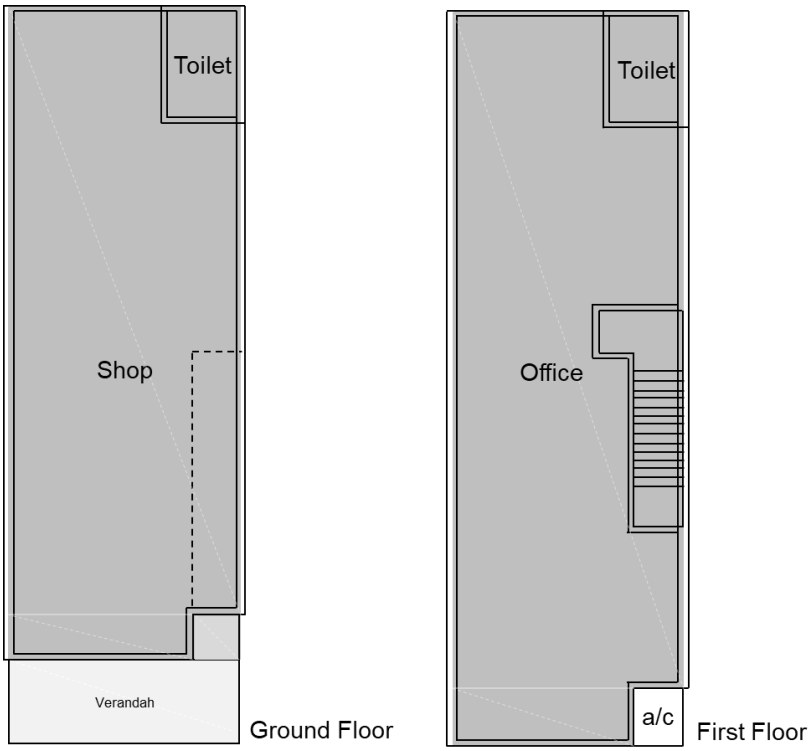


(Courtesy from IHSAN Homes: CIDB, CREAM and JA, 2021)

Figure 2: Shaded Area Shows the GFA for Building

(Courtesy from Ministry of Housing and Local Government (MHLG), 2021)

Figure 3: Shaded Area Shows the GFA for Shop Office



(Courtesy from Malaysian Institute of Architects (PAM))

Figure 4: Shaded Area Shows the GFA for High Rise Development

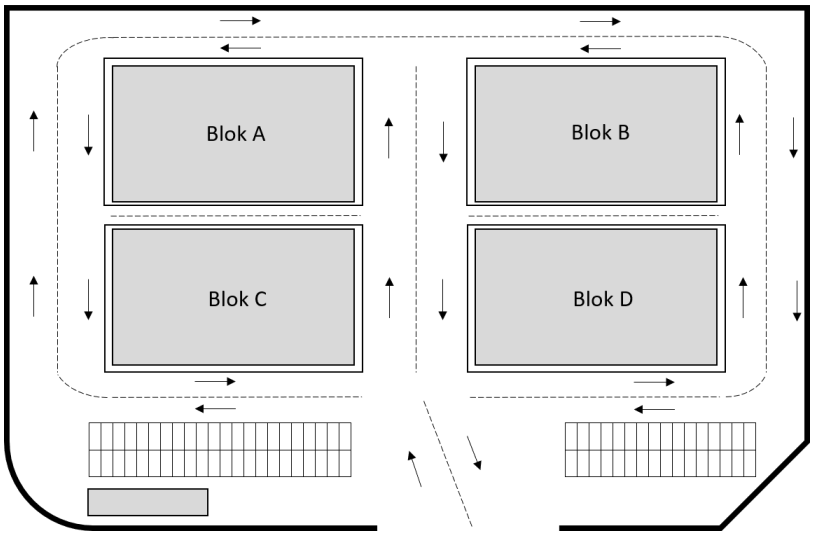
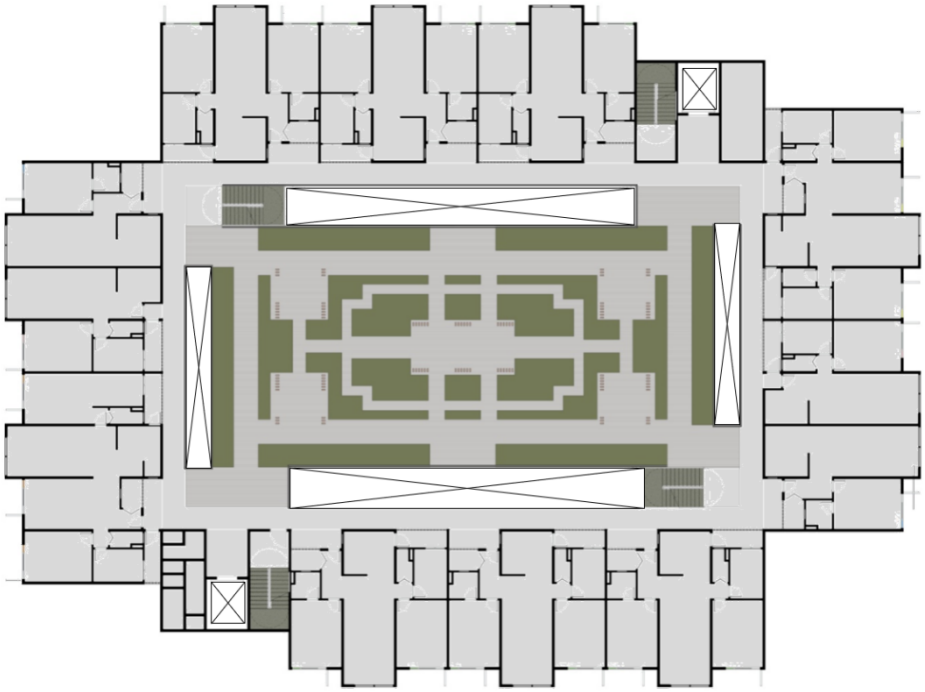


Figure 5: Shaded Area Shows the GFA for Floor



(Courtesy from DeLIGHT Homes: CIDB, CREAM and JA, 2019)

Where:

- The Constructed Gross Floor Area (GFA) is the total property floor area, as measured between the exterior walls of the building(s). Common “vertical circulation”, such as lifts and M&E risers, is particularly excluded from GFA.

- Total man-days are total number of manpower x total period of construction (days)

SECTION 3: PRODUCTIVITY MEASUREMENT

Table 6: Project-Based Productivity Measurement

Building Systems	PROJECT STAGES								
	Design		Production		Logistics	Installation		Construction	
	CSA	MEP	CSA	MEP		CSA	MEP	CSA	MEP
	Number of Manpower (pax)								
Precast Concrete	e.g. A	e.g. B	e.g. C	e.g. D	e.g. E	e.g. F	e.g. G	e.g. H	e.g. I
Metal Framing									
Reusable Formwork									
Blockwork									
Timber Framing									
Innovative									
Prefabricated Prefinished Volumetric Construction (PPVC)									
Conventional									
Gross Floor Area (sq. ft.)									
Total No. of Manpower (pax)	e.g. A + B + C + D + E + F + G + H + I								
Total Construction Period (months)									
Working days/month	e.g. 26 days/month								
Total man-days (Total no of manpower x Total construction period x working days/month)									
Project Productivity Performance (sq. ft./man-day) *refer Equation 1									
Grade of Productivity Performance *refer Table 4									

Table 7: Site-Based Productivity Measurement

Building Systems	Construction Work Stages			
	Installation		Construction	
	CSA	MEP	CSA	MEP
	Number of Manpower (pax)			
Precast Concrete	e.g. A	e.g. B	e.g. C	e.g. D
Metal Framing				
Reusable Formwork				
Blockwork				
Timber Framing				
Innovative				
Prefabricated Prefinished Volumetric Construction (PPVC)				
Conventional				
Gross Floor Area (sq. ft.)				
Total No of Manpower (pax)	e.g. A + B + C + D			
Total Construction Period (months)				
Working days/month				
Man-days (Total no. of manpower x Total construction period x no. of working days/month)				
Productivity Performance (sq. ft./man-day) *refer Equation 1				
Grade of Productivity Performance *refer Table 5				

SECTION 4: PRODUCTIVITY CALCULATION EXAMPLES

Table 8: Project-Based Productivity Measurement Example

Building Systems	PROJECT STAGES								
	Design (A)		Production (B)		Logistics (C)	Installation (D)		Construction (E)	
	CSA	MEP	CSA	MEP		CSA	MEP	CSA	MEP
	Number of Manpower (pax)								
Precast Concrete	2		20		-	13		13	
Metal Framing									
Reusable Formwork									
Blockwork									
Timber Framing									
Innovative									
Prefabricated Prefinished Volumetric Construction (PPVC)									
Conventional									
Gross Floor Area (sq. ft.)	48,437								
Total No of Manpower (pax)	48								
Total Construction Period (months)	4								
Working days/month	26								
Total man-days (Total no of manpower x Total construction period x working days/month)	48 x 4 x 26 = 4,992 man-days								
Project Productivity Performance (sq. ft./man-day) *refer Equation 1	9.70 sq. ft./man-day								
Grade of Productivity Rate *refer **Table *4***	B								

Table 9: Site-Based Productivity Measurement Example

Building Systems	Construction Work Stages			
	Installation		Construction	
	CSA	MEP	CSA	MEP
	Number of Manpower (pax)			
Precast Concrete	13		13	
Metal Framing				
Reusable Formwork				
Blockwork				
Timber Framing				
Innovative				
Prefabricated Prefinished Volumetric Construction (PPVC)				
Conventional				
Gross Floor Area (sq. ft.)	48,437			
Total No of Manpower (pax)	26			
Total Construction Period (months)	4			
No. of Working days/month	26			
Total Man-days (Total no of manpower x Total construction period x no. of working days/month)	26 x 4 x 26 = 2,704 man-days			
Productivity Performance (sq. ft./man-day) *refer **Equation *1***	17.91 sq. ft./man-day			
Grade of Productivity Rate *refer **Table *5***	A			

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ACKNOWLEDGEMENT

Construction Industry Development Board, Malaysia would like to extend our sincere appreciation to all parties involved in developing this standard.

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e ISBN 978-967-2971-39-9